

U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE		ATTORNEY'S DOCKET NUMBER 1642.1002
TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371		
INTERNATIONAL APPLICATION NO. PCT/JP00/04922	INTERNATIONAL FILING DATE July 24, 2000	PRIORITY DATE CLAIMED July 23, 1999 and September 27, 1999
TITLE OF INVENTION RESIN-CEMENTED OPTICAL ELEMENT PROCESS FOR ITS PRODUCTION AND OPTICAL ARTICLE		
APPLICANT(S) FOR DO/EO/US Akiko MIYAKAWA, et al.		
Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:		
1. <input checked="" type="checkbox"/> This is a FIRST submission of items concerning a filing under 35 U.S.C. 371. 2. <input checked="" type="checkbox"/> This is an express request to immediately begin national examination procedures (35 U.S.C. 371(f)). 3. <input type="checkbox"/> The US has been elected by the expiration of 19 months from the priority date (PCT Article 31). 4. <input checked="" type="checkbox"/> A copy of the International Application as filed (35 U.S.C. 371(c)(2)) a. <input type="checkbox"/> is transmitted herewith (required only if not transmitted by the International Bureau). b. <input checked="" type="checkbox"/> has been transmitted by the International Bureau. c. <input type="checkbox"/> is not required, as the application was filed in the United States Receiving Office (RQ/US). 5. <input type="checkbox"/> A translation of the International Application into English (35 U.S.C. 371(c)(2)). 6. <input type="checkbox"/> Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371(c)(3)) a. <input type="checkbox"/> are transmitted herewith (required only if not transmitted by the International Bureau). b. <input type="checkbox"/> have been transmitted by the International Bureau. c. <input type="checkbox"/> is not required, as the application was filed in the United States Receiving Office (RQ/US). 7. <input type="checkbox"/> A translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)). 8. <input checked="" type="checkbox"/> An oath or declaration of the inventor (35 U.S.C. 371(c)(4)). 9. <input type="checkbox"/> A translation of the Annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).		
Items 10-15 below concern document(s) or information included:		
10. <input checked="" type="checkbox"/> An Information Disclosure Statement Under 37 CFR 1.97 and 1.98. 11. <input checked="" type="checkbox"/> An assignment document for recording. Please mail the recorded assignment document to: a. <input checked="" type="checkbox"/> the person whose signature, name & address appears at the bottom of this document. b. <input type="checkbox"/> the following: 12. <input checked="" type="checkbox"/> A preliminary amendment. 13. <input type="checkbox"/> A substitute specification 14. <input type="checkbox"/> A change of power of attorney and/or address letter. 15. <input checked="" type="checkbox"/> Other items or information: WO 01/07938 (1 page) Amendment Under Article 34 (5 pp.)		

10/031602

JC13 Form 1602 23 JAN 2002

The U.S. National Fee (35 U.S.C. 371(c)(1)) and other fees as follows:

CLAIMS	(1) FOR	(2) NUMBER FILED	(3) NUMBER EXTRA	(4) RATE	(5) CALCULATIONS
	TOTAL CLAIMS	34 -20=	14	x \$ 18.00	252.00
	INDEPENDENT CLAIMS	4 -3=	1	x \$ 84.00	84.00
	MULTIPLE DEPENDENT CLAIM(S) (if applicable)			+\$280.00	0.00
	BASIC NATIONAL FEE (37 CFR 1.492(a)(1)-(4):				
	<input type="checkbox"/> Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO\$1,040				
	<input checked="" type="checkbox"/> International preliminary examination fee (37 C.F.R. 1.482) not paid to USPTO but International Search Report prepared by the EPO or JPO.....\$ 890				890.00
	<input type="checkbox"/> International preliminary examination fee (37 C.F.R. 1.482) not paid to USPTO but international search fee (37 C.F.R. 1.445(a)(2) paid to USPTO...\$ 740				
	<input type="checkbox"/> International preliminary examination fee paid to USPTO (37 CFR 1.482) but all claims did not satisfy provision of PCT Article 33(1)-(4).....\$ 710				
	<input type="checkbox"/> International preliminary examination fee paid to USPTO (37 CFR 1.482) and all claims satisfied provisions of PCT Article 33(2) to (4)\$ 100				
	Surcharge of \$130 for furnishing the National fee or oath or declaration later than				
	<input type="checkbox"/> 20 <input type="checkbox"/> 30 mos. from the earliest claimed priority date (37 CFR 1.482(e)).				0.00
			TOTAL OF ABOVE CALCULATIONS		1226.00
	Reduction by 1/2 for filing by small entity, if applicable. Affidavit must be filed also. (Note 37 CFR 1.9, 1.27, 1.28.)				
			SUBTOTAL		1226.00
	Processing fee of \$130 for furnishing the English Translation later than				
	[] 20 [] 30 mos. from the earliest claimed priority date (37 CFR 1.482(f)).				
			TOTAL NATIONAL FEE		1226.00
	Fee for recording the enclosed assignment (37 CFR 1.21(h)).			+	40.00
			TOTAL FEES ENCLOSED		1266.00

a. A checks in the amount of \$1226.00 and 40.00 to cover the above fees is enclosed.
 b. Please charge my Deposit Account No. 19-3935 in the Amount of \$ to cover the above fees. A duplicate copy of this sheet is enclosed.
 c. The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. 19-3935. A duplicate copy of this sheet is enclosed.



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PATENT TRADEMARK OFFICE

SUBMITTED BY: STAAS & HALSEY LLP

Type Name	David M. Pitcher	Reg. No.	25,908
Signature		Date	January 23, 2002

10/031602

JC13 Rec'd PCT/PTO 23 JAN 2002

Docket No.: 1642.1002

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re the Application Under 35 U.S.C. §371 of
(PCT/JP00/04922):

Akiko MIYAKAWA, et al.

Serial No. Group Art Unit: Unassigned

Confirmation No.

Filed: January 23, 2002 Examiner: Unassigned

For: RESIN-CEMENTED OPTICAL ELEMENT PROCESS FOR ITS PRODUCTION AND
OPTICAL ARTICLE

PRELIMINARY AMENDMENT

Assistant Commissioner for Patents
Washington, D.C. 20231

Sir:

Before examination of the above-identified application, please amend the application as follows:

IN THE SPECIFICATION:

Please REPLACE on page 14, paragraph one (1), on page 15, paragraph two (2), and on page 27, paragraph two (2) with the following new paragraphs:

In general, resins change in refractive index before and after curing. Hence, in order to attain the desired refractive index after curing, the composition of the resin must be determined taking account of the changes in refractive index before and after curing. Accordingly, in respect of the above resin composition, changes in refractive index before and after curing have been studied in detail. As the result, it has been ascertained that the refractive index after curing comes to 1.55 or more when the refractive index before curing is 1.52 or more. Thus, the photosensitive resin composition in the present invention may preferably have a refractive index before curing of 1.52 or more.

As a result of extensive studies, the present inventors have discovered that a di(meth)acrylate represented by the following Formula (1) is particularly preferred as the component (A). Of the di(meth)acrylate represented by Formula (1), one having a molecular weight of 1,000 or less is more preferred because of its large refractive index.

Incidentally, the mechanism is unclear as to the phenomenon that the light transmittance and degree of cure of the resin are improved by the heating. It, however, can be presumed that, the heating accelerates the post-curing (a phenomenon that the curing of photosensitive resin proceeds gradually also after exposure) of the resin to enhance the degree of cure, and also, since in the heating step the curing reaction proceeds, the chemical structure of the resin is not destroyed by light and on the contrary any slight absorption sources caused in the resin layer at the time of curing are remedied on.

Please DELETE paragraph two (2) on page 39, lines 12-14.

IN THE CLAIMS:

Please AMEND the pending claims 1, 5, 7-9, 11-13, 15-16, 22, 34-36 and 38-39, CANCEL claims 2-4, 6, 23-30 and 40, and ADD new claims 41-47 in accordance with the following:

1. (ONCE AMENDED) An optical element comprising:

a base member; and

a resin layer formed on the surface of the base member and comprising a cured product of a photosensitive resin composition, wherein said resin layer has at least one of the following features:

- (a) a refractive index of 1.55 or more,
- (b) a visible light inner transmittance of 95% or more in a 100 mm thick area,
- (c) a rate of hygroscopic dimensional change of 0.4% or less,
- (d) a durometer hardness of HDD 70 or more; and
- (e) a glass transition temperature of 95°C or above.

5. (ONCE AMENDED) The optical element according to claim 1, wherein said resin layer having a gel percentage of 95% or more.

7. (ONCE AMENDED) The optical element according to claim 1, wherein said photosensitive resin composition having a rate of shrinkage on curing of 7% or less.

8. (ONCE AMENDED) The optical element according to claim 1, wherein said resin composition comprises:

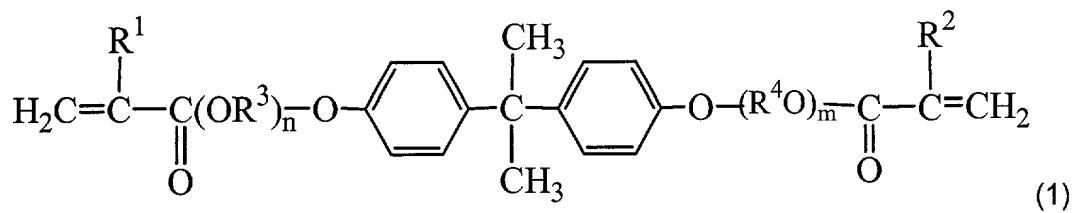
- (A) a polyfunctional (meth)acrylate;
- (B) a polyfunctional urethane-modified (meth)acrylate; and
- (C) a photopolymerization initiator.

9. (ONCE AMENDED) The optical element according to claim 1, wherein said resin composition has a refractive index before polymerization curing of, 1.52 or more.

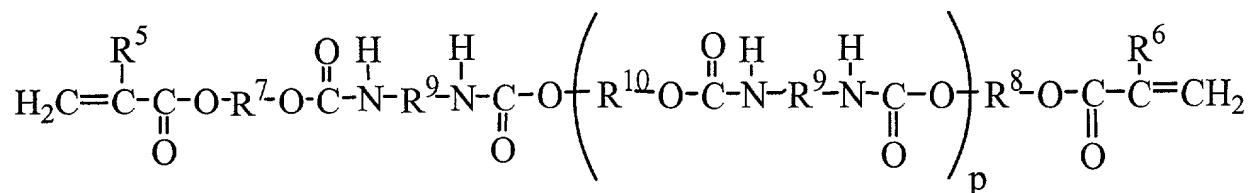
10. (ONCE AMENDED) The optical element according to claim 8, wherein said polyfunctional (meth)acrylate has a refractive index before polymerization curing, of 1.53 or more.

11. (ONCE AMENDED) The optical element according to claim 8, wherein said polyfunctional (meth)acrylate has two or more benzene ring structures in one molecule.

12. (ONCE AMENDED) The optical element according to claim 8, wherein said resin composition comprising, as at least a part of said polyfunctional (meth)acrylate, a di(meth)acrylate represented by the following Formula (1):



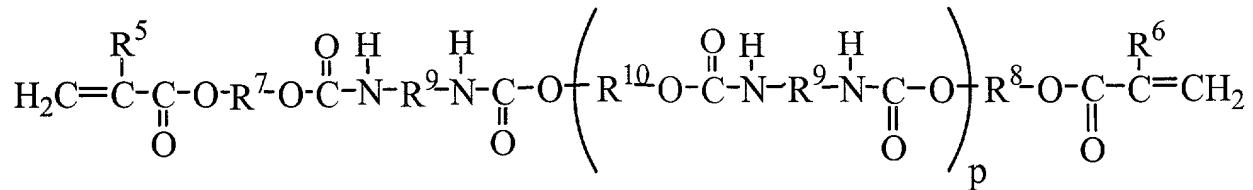
wherein R1 and R2 are each a hydrogen atom or a methyl group, R3 and R4 are each a hydrocarbon group having 2 to 4 carbon atoms, and m and n are each an integer of 1 or more.



13. (ONCE AMENDED) The optical element according to claim 8, wherein said polyfunctional (meth)acrylate has a molecular weight before polymerization curing, of 1,000 or less.

14. (UNAMENDED) The optical element according to claim 8, wherein said polyfunctional urethane modified (meth)acrylate has a refractive index before polymerization curing, of 1.48 or more.

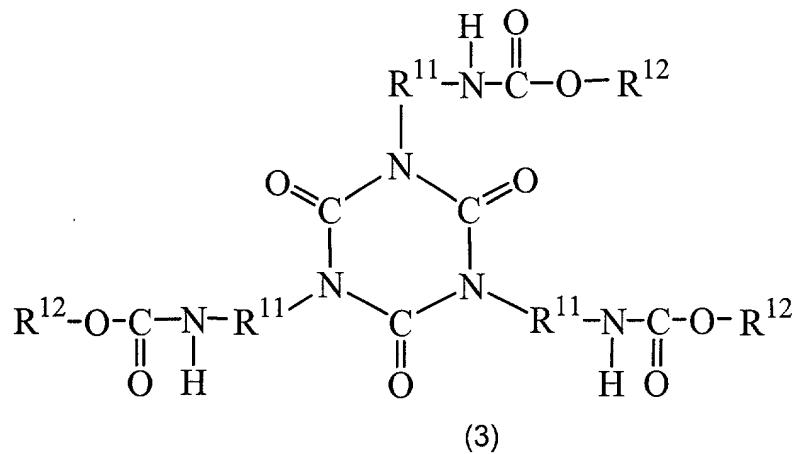
15. (ONCE AMENDED) The optical element according to claim 8, wherein said polyfunctional urethane modified (meth)acrylate contains at least one of compounds represented



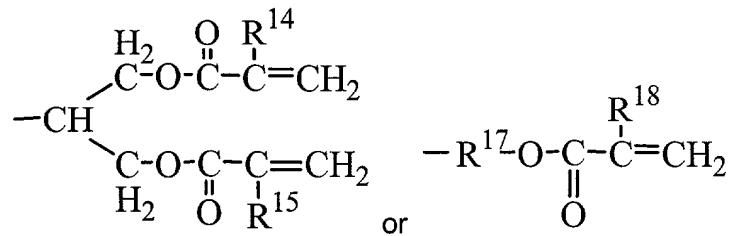
by any of the following Formulas (2) to (4):

(2)

wherein R⁵ and R⁶ are each a hydrogen atom or a methyl group, R⁷ and R⁸ are each a hydrocarbon group having 1 to 10 carbon atoms, R⁹ is an isocyanate residual group, R¹⁰ is a polyol residual group or a polyester residual group, and p is 0 or an integer of 10 or less.

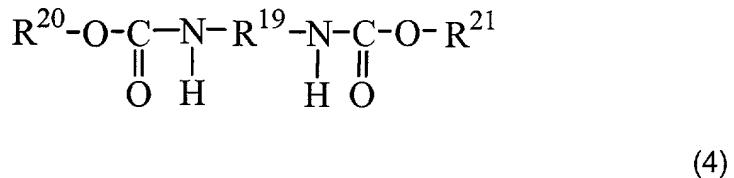


wherein R¹¹ is a hydrocarbon group having 1 to 10 carbon atoms, and R¹² is

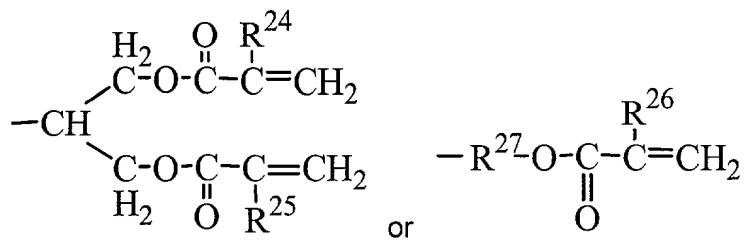


or

wherein R¹⁴, R¹⁵ and R¹⁸ are each a hydrogen atom or a methyl group, and R¹⁷ is a hydrocarbon group having 1 to 10 carbon atoms;



wherein R¹⁹ is a hydrocarbon group having 1 to 10 carbon atoms, and R²⁰ and R²¹ are each



wherein R^{24} , R^{25} and R^{26} are each a hydrogen atom or a methyl group, and R^{27} is a hydrocarbon group having 1 to 10 carbon atoms.

16. (ONCE AMENDED) An optical article having the optical element according to claim 1.

17. (UNAMENDED) The optical article according to claim 16, wherein;
said optical element is a lens; and
said optical article is a still camera.

18. (UNAMENDED) The optical article according to claim 16, wherein;
said optical element is a lens; and
said optical article is a video camera.

19. (UNAMENDED) The optical article according to claim 16, wherein;
said optical element is a lens; and
said optical article is an interchangeable lens.

20. (UNAMENDED) A process for producing a resincemented optical element, the process comprising:

a first exposure step of irradiating a photosensitive resin composition held between the surface of a base member and a mold tool, to cure the composition to form a resin layer;

a mold release step of moldreleasing the resin layer; and
a heating step of heating the resin layer, in this order.

21. (UNAMENDED) A process for producing a resincemented optical element, the process comprising:

a first exposure step of irradiating a photosensitive resin composition held between the surface of a base member and a mold tool, with heating to cure the composition to form a resin layer; and

a mold mold release step of moldreleasing the resin layer, in this order.

22. (ONCE AMENDED) The production process according to claim 21, wherein the heating in said first exposure step is carried out at a temperature of from 40°C to 130°C.

31. (UNAMENDED) A process for producing a resincemented optical element, the process comprising one or more exposure steps of irradiating a photosensitive resin composition held between the surface of a base member and a molding tool, to cure the composition to form a resin layer;

at least one of said exposure steps being the step of irradiating the resin composition by light not comprising light with a wavelength of less than 300 nm.

32. (UNAMENDED) The process for producing a resincemented optical element according to claim 31, which further comprises a mold release step of moldreleasing the resin layer;

said step of irradiating the resin composition by the light not comprising light with a wavelength of less than 300 nm being a first exposure step carried out before said mold release step.

33. (UNAMENDED) The process for producing a resin cemented optical element according to claim 31, which further comprises a mold release step of mold releasing the resin layer;

said step of irradiating the resin composition by the light not comprising light with a wavelength of less than 300 nm being a second exposure step carried out after said mold release step.

34. (ONCE AMENDED) The process for producing a resin cemented optical element according to claim 20, which further comprises, after said mold release step, a second exposure step of irradiating the resin layer by light not comprising light with a wavelength of less than 300 nm.

35. (ONCE AMENDED) The production process according to claim 31, wherein the irradiation in the step of irradiation by the light not comprising light with a wavelength of less than 300 nm is performed shutting out light with a wavelength of less than 300 nm among light emitted from a light source.

36. (ONCE AMENDED) The production process according to any one of claim 21, which further comprises, after said mold release step, a heating step of heating the resin layer.

37. (ONCE AMENDED) The production process according to claim 33, which further comprises, after said second exposure step, a heating step of heating the resin layer.

38. (ONCE AMENDED) The production process according to claim 20, wherein the heating in said heating step is carried out at a temperature of from 40°C to 130°C.

39. (ONCE AMENDED) The production process according to claim 20, wherein said resin composition comprises:

- (A) a polyfunctional (meth)acrylate;
- (B) a polyfunctional urethane-modified (meth)acrylate; and
- (C) a photopolymerization initiator.

41. (NEW) The process for producing a resin cemented optical element according to claim 21, which further comprises, after said mold release step, a second exposure step of irradiating the resin layer by light not comprising light with a wavelength of less than 300 nm.

42. (NEW) The process for producing a resin cemented optical element according to claim 32, which further comprises, after said mold release step, a second exposure step of irradiating the resin layer by light not comprising light with a wavelength of less than 300 nm.

43. (NEW) The production process according to claim 36, wherein the heating in said heating step is carried out at a temperature of from 40°C to 130°C.

44. (NEW) The production process according to claim 37, wherein the heating in said heating step is carried out at a temperature of from 40°C to 130°C.

45. (NEW) The production process according to claim 21, wherein said resin composition comprises:

- (A) a polyfunctional (meth)acrylate;
- (B) a polyfunctional urethane-modified (meth)acrylate; and
- (C) a photopolymerization initiator.

46. (NEW) The production process according to claim 31, wherein said resin composition comprises:

- (A) a polyfunctional (meth)acrylate;
- (B) a polyfunctional urethane-modified (meth)acrylate; and
- (C) a photopolymerization initiator.

47. (NEW) The production process according to claim 32, which further comprises, after said mold release step, a heating step of heating the resin layer.

REMARKS

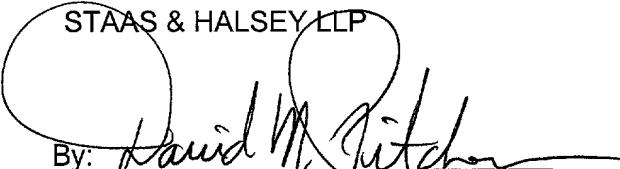
This Preliminary Amendment is submitted to improve the form of the specification as originally-filed and to correct obvious errors. In addition, original claims 1, 5, 7-9, 11-13, 15-16, 22, 34-36 and 38-39 are amended, claims 2-4, 6, 23-30, and 40 cancelled, and new claims 41-47 are added. No new matter is added.

It is respectfully requested that this Preliminary Amendment be entered in the above-referenced application.

If there are any additional fees associated with filing of this Preliminary Amendment, please charge the same to our Deposit Account No. 19-3935.

Respectfully submitted,

STAAS & HALSEY LLP

By: 
David M. Pitcher
Registration No. 25,908

Date:

January 23, 2002

700 Eleventh Street, NW, Suite 500
Washington, D.C. 20001
(202) 434-1500

VERSION WITH MARKINGS TO SHOW CHANGES MADE

IN THE SPECIFICATION:

Please REPLACE on page 14, paragraph one (1), on page 15, paragraph two (2) and on page 27, paragraph two (2) with the following new paragraphs:

In general, resins change in refractive index before and after curing. Hence, in order to attain the desired refractive index after curing, the composition of the resin must be determined taking account of the changes in refractive index before and after curing. Accordingly, in respect of the above resin composition, changes in refractive index before and after curing have been studied in detail. As the result, it has been ascertained that the refractive index after curing comes to 1.55 or more when the refractive index before curing is 1.52 or more. Thus, the photosensitive resin composition in the present invention may preferably have a refractive index before curing of 1.52 or more.

As a result of extensive studies, the present inventors have discovered that a di(meth)acrylate represented by the following Formula (1) is particularly preferred as the component (A). Of the di(meth)acrylate represented by Formula (1), one having a molecular weight of 1,000 or less is more preferred because of its [small] large refractive index.

Incidentally, the mechanism is unclear as to the phenomenon that the light transmittance and degree of cure of the resin are improved by the heating. It, however, can be presumed that, the heating accelerates the post-curing (a phenomenon that the curing of photosensitive resin proceeds gradually also after exposure) of the resin to enhance the degree of cure, and also, since in the heating step the curing reaction proceeds [without the exposure], the chemical structure of the resin is not destroyed by light and on the contrary any slight absorption sources caused in the resin layer at the time of curing are remedied on.

Please DELETE paragraph two (2) on page 39, lines 12-14.

[Physical properties of the resin composition before curing and of the resin after curing which were measured in the same manner as in Example were as shown in Table 1.]

IN THE CLAIMS:

Please CANCEL claims 2-4, 6, 23-30 and 40 .

Please AMEND the following claims 1, 5, 7-9, 11-13, 15-16, 22, 34-36 and 38-39:

Please ADD the following claims 41-47:

1. (ONCE AMENDED) An optical element comprising:

a base member; and

a resin layer formed on the surface of the base member and comprising a cured product of a photosensitive resin composition, wherein said resin layer has at least one of the following features:

(a) a refractive index of 1.55 or more,

(b) a visible-light inner transmittance of 95% or more in a 100 μm thick area,

(c) a rate of hygroscopic dimensional change of 0.4% or less,

(d) a durometer hardness of HDD 70 or more; and

(e) a glass transition temperature of 95°C or above.

2. (cancel)

3. (cancel)

4. (cancel)

5. (ONCE AMENDED) The optical element according to [any one of claims 1 to 4] claim1, [comprising:

the base member;

and the resin layer formed on the surface of the base member and comprising a cured product of a photosensitive resin composition;]

wherein said resin layer having a gel percentage of 95% or more.

6. (cancel)

7. (ONCE AMENDED) The optical element according to [any one of claims 1 to 6] claim 1, [comprising;

the base member; and

the resin layer formed on the surface of the base member and comprising a cured product of a photosensitive resin composition;]

wherein said photosensitive resin composition having a rate of shrinkage on curing of 7% or less.

8. (ONCE AMENDED) The optical element according to [any one of claims 1 to 7] claim 1, wherein said resin composition comprises:

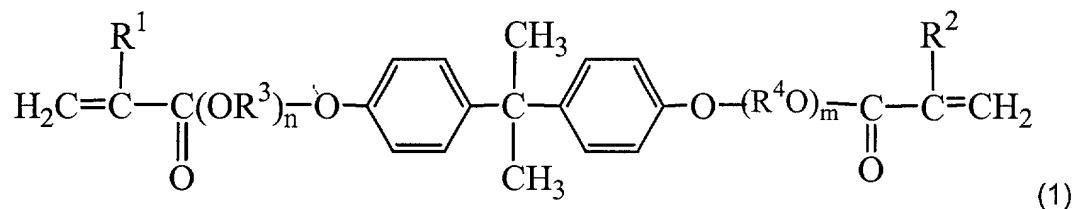
- (A) a polyfunctional (meth)acrylate;
- (B) a polyfunctional urethane-modified (meth)acrylate; and
- (C) a photopolymerization initiator.

9. (ONCE AMENDED) The optical element according to [any one of claims 1 to 8] claim 1, wherein said resin composition has a refractive index before polymerization curing of, 1.52 or more.

10. (UNAMENDED) The optical element according to claim 8, wherein said polyfunctional (meth)acrylate has a refractive index before polymerization curing, of 1.53 or more.

11. (ONCE AMENDED) The optical element according to [any one of claims 8 to 10] claim 8, wherein said polyfunctional (meth)acrylate has two or more benzene ring structures in one molecule.

12. (ONCE AMENDED) The optical element according to [any one of claims 8 to 11] claim 8, wherein said resin composition comprising, as at least a part of said polyfunctional (meth)acrylate, a di(meth)acrylate represented by the following Formula (1):

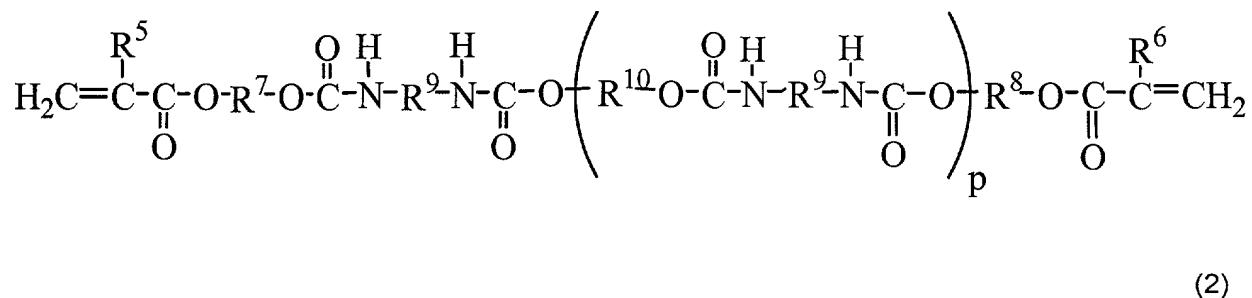


wherein R1 and R2 are each a hydrogen atom or a methyl group, R3 and R4 are each a hydrocarbon group having 2 to 4 carbon atoms, and m and n are each an integer of 1 or more.

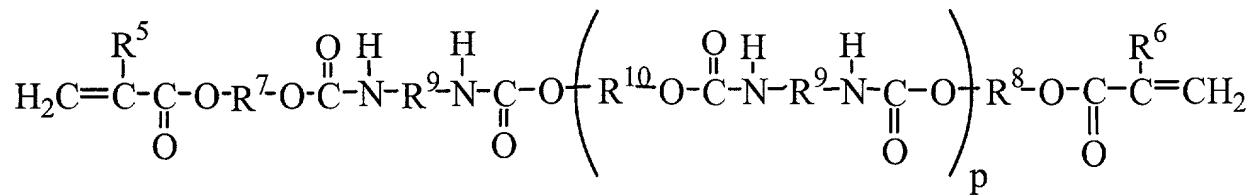
13. (ONCE AMENDED) The optical element according to [any one of claims 8 to 12] claim 8, wherein said polyfunctional (meth)acrylate has a molecular weight before polymerization curing, of 1,000 or less.

14. (UNAMENDED) The optical element according to claim 8, wherein said polyfunctional urethane-modified (meth)acrylate has a refractive index before polymerization curing, of 1.48 or more.

15. (ONCE AMENDED) The optical element according to [any one of claims 8 to 14] claim 8, wherein said polyfunctional urethane-modified (meth)acrylate contains at least one of compounds represented by any of the following Formulas (2) to (4):

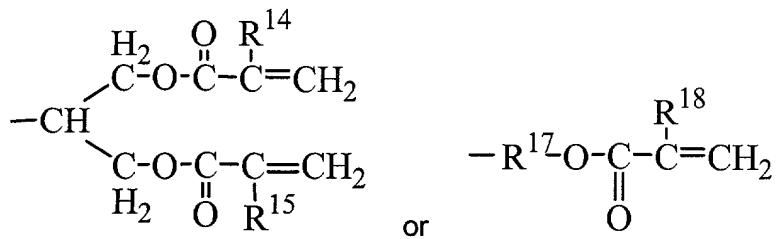


wherein R⁵ and R⁶ are each a hydrogen atom or a methyl group, R⁷ and R⁸ are each a hydrocarbon group having 1 to 10 carbon atoms, R⁹ is an isocyanate residual group, R¹⁰ is a polyol residual group or a polyester residual group, and p is 0 or an integer of 10 or less.

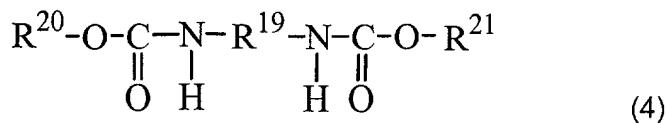


(3)

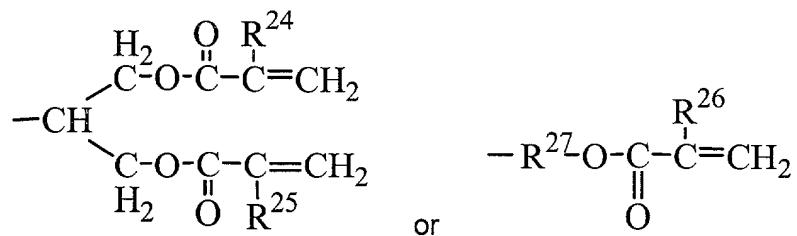
wherein R^{11} is a hydrocarbon group having 1 to 10 carbon atoms, and R^{12} is



wherein R^{14} , R^{15} and R^{18} are each a hydrogen atom or a methyl group, and R^{17} is a hydrocarbon group having 1 to 10 carbon atoms;



wherein R^{19} is a hydrocarbon group having 1 to 10 carbon atoms, and R^{20} and R^{21} are each



wherein R^{24} , R^{25} and R^{26} are each a hydrogen atom or a methyl group, and R^{27} is a hydrocarbon group having 1 to 10 carbon atoms.

16. (ONCE AMENDED) An optical article having the optical element according to [any one of claims 1 to 15] claim 1.

17. (UNAMENDED) The optical article according to claim 16, wherein; said optical element is a lens; and said optical article is a still camera.

18. (UNAMENDED) The optical article according to claim 16, wherein; said optical element is a lens; and
said optical article is a video camera.

19. (UNAMENDED) The optical article according to claim 16, wherein; said optical element is a lens; and
said optical article is an interchangeable lens.

20. (UNAMENDED) A process for producing a resin-cemented optical element, the process comprising:

a first exposure step of irradiating a photosensitive resin composition held between the surface of a base member and a mold tool, to cure the composition to form a resin layer;
a mold release step of mold-releasing the resin layer; and
a heating step of heating the resin layer,
in this order.

21. (UNAMENDED) A process for producing a resin-cemented optical element, the process comprising:

a first exposure step of irradiating a photosensitive resin composition held between the surface of a base member and a mold tool, with heating to cure the composition to form a resin layer; and

a mold mold release step of mold-releasing the resin layer,

in this order.

22. (ONCE AMENDED) The production process according to claim 21, wherein the heating in said first exposure step is carried out at a temperature of from 40°C to 130°C.

23. - 30. (cancel under PCT Article 34)

31. (UNAMENDED) A process for producing a resin-cemented optical element, the process comprising one or more exposure steps of irradiating a photosensitive resin composition held between the surface of a base member and a molding tool, to cure the composition to form a resin layer;

at least one of said exposure steps being the step of irradiating the resin composition by light not comprising light with a wavelength of less than 300 nm.

32. (UNAMENDED) The process for producing a resin-cemented optical element according to claim 31, which further comprises a mold release step of mold-releasing the resin layer;

said step of irradiating the resin composition by the light not comprising light with a wavelength of less than 300 nm being a first exposure step carried out before said mold release step.

33. (UNAMENDED) The process for producing a resin-cemented optical element according to claim 31, which further comprises a mold release step of mold-releasing the resin layer;

 said step of irradiating the resin composition by the light not comprising light with a wavelength of less than 300 nm being a second exposure step carried out after said mold release step.

34. (ONCE AMENDED) The process for producing a resin-cemented optical element according to [any one of claims 20, 21 and 32] claim 20, which further comprises, after said mold release step, a second exposure step of irradiating the resin layer by light not comprising light with a wavelength of less than 300 nm.

35. (ONCE AMENDED) The production process according to [any one of claims 31 to 34] claim 31, wherein the irradiation in the step of irradiation by the light not comprising light with a wavelength of less than 300 nm is performed shutting out light with a wavelength of less than 300 nm among light emitted from a light source.

36. (ONCE AMENDED) The production process according to any one of [claims 21 and 32 to 34] claim 21, which further comprises, after said mold release step, a heating step of heating the resin layer.

37. (UNAMENDED) The production process according to claim 33, which further comprises, after said second exposure step, a heating step of heating the resin layer.

38. (ONCE AMENDED) The production process according to [any one of claims 20, 36 and 37] claim 20, wherein the heating in said heating step is carried out at a temperature of from 40°C to 130°C.

39. (ONCE AMENDED) The production process according to [any one of claims 20, 21, 31, 32 and 33] claim 20, wherein said resin composition comprises:

- (A) a polyfunctional (meth)acrylate;
- (B) a polyfunctional urethane-modified (meth)acrylate; and
- (C) a photopolymerization initiator.

40. (cancel)

41. (NEW) The process for producing a resincemented optical element according to claim 21, which further comprises, after said mold release step, a second exposure step of irradiating the resin layer by light not comprising light with a wavelength of less than 300 nm.

42. (NEW) The process for producing a resincemented optical element according to claim 32, which further comprises, after said mold release step, a second exposure step of irradiating the resin layer by light not comprising light with a wavelength of less than 300 nm.

43. (NEW) The production process according to claim 36, wherein the heating in said heating step is carried out at a temperature of from 40°C to 130°C.

44 (NEW) The production process according to claim 37, wherein the heating in said heating step is carried out at a temperature of from 40°C to 130°C.

45. (NEW) The production process according to claim 21, wherein said resin composition comprises:

- (A) a polyfunctional (meth)acrylate;
- (B) a polyfunctional urethane-modified (meth)acrylate; and
- (C) a photopolymerization initiator.

46. (NEW) The production process according to claim 31, wherein said resin composition comprises:

- (A) a polyfunctional (meth)acrylate;
- (B) a polyfunctional urethane-modified (meth)acrylate; and
- (C) a photopolymerization initiator.

47. (NEW) The production process according to claim 32, which further comprises, after said mold release step, a heating step of heating the resin layer.

Amendment under Article 34

5. (amended)

The optical element according to any one of claims 1 to 4, comprising:

the base member; and

the resin layer formed on the surface of the base member and comprising a cured product of a photosensitive resin composition, wherein said resin layer has a gel percentage of 95% or more.

7. (amended)

The optical element according to any one of claims 1 to 6, comprising:

the base member; and

the resin layer formed on the surface of the base member and comprising a cured product of a photosensitive resin composition, wherein said photosensitive resin composition has a rate of shrinkage on curing of 7% or less.

23. (cancelled)

24. (cancelled)

25. (cancelled)

26. (cancelled)

27. (cancelled)

28. (cancelled)

29. (cancelled)

30. (cancelled)

31. (added)

A process for producing a resin-cemented optical element, the process comprising one or more exposure steps of irradiating a photosensitive resin composition held between the surface of a base member and a molding tool, to cure the composition to form a resin layer, wherein

at least one of said exposure steps being the step of irradiating the resin composition by light not comprising light with a wavelength of less than 300 nm.

32. (added)

The process for producing a resin-cemented optical element according to claim 31, which further comprises a mold release step of mold-releasing the resin layer, wherein

said step of irradiating the resin composition by the light not comprising light with a wavelength of less than 300 nm being a first exposure step carried out before said mold release step.

33. (added)

The process for producing a resin-cemented optical element according to claim 31, which further comprises a mold release step of mold-releasing the resin layer, wherein

said step of irradiating the resin composition by the light

not comprising light with a wavelength of less than 300 nm being a second exposure step carried out after said mold release step.

34. (added)

The process for producing a resin-cemented optical element according to any one of claims 20, 21 and 32, which further comprises, after said mold release step, a second exposure step of irradiating the resin layer by light not comprising light with a wavelength of less than 300 nm.

35. The production process according to any one of claims 31 to 34, wherein the irradiation in the step of irradiation by the light not comprising light with a wavelength of less than 300 nm is performed shutting out light with a wavelength of less than 300 nm among light emitted from a light source.

36. (added)

The production process according to any one of claims 21 and 32 to 34, which further comprises, after said mold release step, a heating step of heating the resin layer.

37. (added)

The production process according to claim 33, which further comprises, after said second exposure step, a heating step of heating the resin layer.

38. (added)

The production process according to any one of claims 20, 36 and 37, wherein the heating in said heating step is carried out at a temperature of from 40°C to 130°C.

39. (added)

The production process according to any one of claims 20, 21, 31, 32 and 33, wherein said resin composition comprises:

- (A) a polyfunctional (meth)acrylate;
- (B) a polyfunctional urethane-modified (meth)acrylate; and
- (C) a photopolymerization initiator.

40. The optical element according to any one of claims 1 to 4, comprising:

the base member; and

the resin layer formed on the surface of the base member and comprising a cured product of a photosensitive resin composition, wherein said resin layer has a glass transition temperature of 95°C or above.

Amendment under Article 34

IN THE SPECIFICATION

Please make an amendment as follows:

page 15, lines 17 to 18, change "its small refractive index" to "its large refractive index."

2/Pyb

PCT/JP00/04922

DESCRIPTION

RESIN-CEMENTED OPTICAL ELEMENT,

PROCESS FOR ITS PRODUCTION

5

AND

OPTICAL ARTICLE

TECHNICAL FIELD

This invention relates to a resin-cemented optical element having a
10 resin layer formed on the surface of a base member, a process for its
production, and an optical article having the element.

BACKGROUND ART

At present, optical elements are used in various fields. Depending
15 on the purpose for which they are used, it is difficult to materialize
required optical characteristics and so forth in some cases in respect of
conventional spherical lenses comprised only of glass. Accordingly,
resin-cemented optical elements comprising a base member provided
thereon with a cured resin layer having a stated shape are attracting
20 notice.

For example, in order to make optical elements such as camera
lenses compact and light-weight, it is important to lessen the number of
component lenses of an optical system. In order to lessen the number of
component lenses, it is effective that a component part constituted of a
25 plurality of spheric lenses is replaced with one aspheric lens.

"Aspheric lens" is a generic term for lenses the curvature of which

is kept continuously different over the region extending from the lens center toward the periphery. The use of aspheric lenses at some part of optical systems enables considerable reduction of the number of lenses necessary for the correction of aberrations, compared with a case in 5 which the optical system is constituted only of spheric lenses. This can make the optical system compact and light-weight. Also, the use of aspheric lenses enables high-grade correction of aberrations which is difficult for spherical lenses, and hence can bring about an improvement in image quality.

10 Aspheric lenses having such superior characteristics have not necessarily come into wide use. The greatest reason therefor can be said to be a difficulty in working. Conventional aspheric lenses make use of base members made of glass, and have only be able to be produced by precisely polishing this glass, having involved the problem of a high cost.

15 In recent years, however, techniques for producing resin-cemented optical elements such as composite-type aspherical-surface molding, plastic molding, and glass molding have been put into practical use one after another, and it has become possible to produce aspheric lenses at a low cost by these methods. Thus, the aspheric lenses have rapidly come 20 into wide use. Nowadays, such aspheric lenses have come into wide use in camera lenses and so forth.

The plastic molding is a method in which a resin is injected into a mold with the desired aspherical shape to effect molding. This method can enjoy a high productivity and a low cost. It, however, has had 25 problems that aspheric lenses thus produced have a limit to their refractive index and moreover are inferior to glass lenses in respect of

figure tolerance and reliability.

The glass molding is a method in which a glass blank material standing softened is shaped in a mold having the desired aspherical shape. This method enables achievement of mass productivity and high 5 precision. It, however, has a limit to the types of glass usable therefor. Moreover, it requires a relatively high molding temperature, and may impose a great load on the mold. Accordingly, how this load be reduced comes into question.

The composite-type aspherical-surface molding is a method in 10 which, using a mold having an aspherical shape, a resin layer having the aspherical shape is provided on a spheric or aspheric glass lens. This method can be said to be a method having both the characteristics, i.e., the reliability the glass lens has and the mass productivity the plastic molding has. In the present specification, a lens produced by this 15 composite-type aspherical-surface molding is called a PAG lens.

Conventional PAG lenses have characteristic features that they can well be mass-produced and are relatively inexpensive. They, however, have problems such that, compared with aspheric lenses made of glass, they have a restriction on the extent of designable aspheric surface, have 20 a low light transmittance, and may change in optical performance depending on environment, resulting in a poor reliability.

As the resin used in this composite-type aspherical-surface molding, it may include thermoplastic resins and photosensitive resins. In the case when aspheric lenses are produced, a method is especially 25 effective in which a composition of photosensitive resin (photo-reactive resin) is made to adhere to the surface of a base member, followed by

irradiation with light such as ultraviolet light to effect curing. However, when such a photosensitive resin is used in the PAG lens resin layer, there is a problem that the shape of the mold can not exactly be transferred especially in the case of a PAG lens having a large extent of 5 aspherical surface, i.e., having a large resin thickness. This imposes a restriction on designing.

Conventional PAG lenses also have a lower light transmittance than glass lenses, and hence the employment of such PAG lenses may possibly lead to a low transmittance of the whole optical system. For 10 this reason, the number of PAG lenses usable in one optical system is usually limited to one or two.

Resin-cemented optical elements such as the PAG lenses also have a problem that they may so greatly change in optical performance depending on environment as to have a poor weatherability. In order to 15 improve the weatherability, it is effective to enhance the degree of cure (degree of polymerization) of the resin, and, in order to do so, it is effective to irradiate the resin by a large amount of light so as to cure the resin further. However, an increase in irradiation level results in a decrease in light transmittance of the resin because of its yellowing. 20 Thus, it is difficult for any conventional techniques to achieve both the improvement in light transmittance and the improvement in weatherability of the resin-cemented optical element.

DISCLOSURE OF THE INVENTION

25 An object of the present invention is to provide a superior resin-cemented optical element having solved the above problems in

conventional PAG lenses, i.e. the problems on the restrictions on optical performance and extent of designable aspherical surface, the weatherability and so forth, and having a high light transmittance (in particular, visible-light inner transmittance).

5 With regard to the aspheric lens having a large extent of aspherical surface, which has hitherto had insufficient optical performance in respect of, e.g., transmittance and been moldable with difficulty and producible only by costly methods, the present inventors have made extensive studies from various points of view in order to produce such an
10 aspheric lens with ease and also to achieve superior optical performance by the use of the aspheric lens, and have discovered the following facts.

1. Characteristics of resin layer:

As a method by which a resin is molded with greater ease than conventional methods without damaging any optical performance having
15 ever been achieved, a method is available in which the resin is made to have a higher refractive index. Namely, by the use of a resin having a higher refractive index, the same effect of aspherical surface as that achievable by the one having a large extent of aspherical surface can be achieved in a smaller extent of aspherical surface. Also, the lens having
20 a small extent of aspherical surface is obtainable in a better moldability than the lens having a large extent of aspherical surface. Thus, it follows that the moldability can be improved by making the refractive index higher. More specifically, in order to make the effect of aspherical surface higher without changing the shape of aspherical surface, it is
25 effective to make the resin have a higher refractive index. In particular, a resin having a refractive index of 1.55 or more enables the aspherical

surface to be designed at a higher freedom, so that an aspheric lens usable for various purposes can be obtained.

Resins used in resin layers of conventional PAG lenses have had a refractive index of about 1.50 on the whole. However, the use of the 5 resin having a refractive index of 1.55 or more enables the resin layer to have a layer thickness thinner than that in conventional cases. This not only makes the moldability higher, but also allows the resin to be used in a small quantity, enabling achievement of cost reduction.

It has also been ascertained that making the resin have a larger 10 refractive index makes the PAG lens have a higher transmittance. This is because the difference in refractive index between the resin constituting the PAG lens and the glass can be made small, so that the light may less reflect at their interface. Hence, the use of the resin having a high refractive index makes it possible to use the PAG lens even 15 in an aspheric lens required to have a higher transmittance. Such a PAG lens having a high transmittance contributes to the improvement of transmittance of the whole optical system and to the prevention of flares.

What is most questioned in optical performance of resin is the transmittance. In general, resin has lower transmittance than glass, and 20 hence PAG lenses often have a transmittance inferior to the transmittance of aspheric lenses made only of glass. The transmittance of resin may lower on account of two factors, the scattering and absorption of light in the interior of the resin. The scattering is caused when the resin does not have any uniform compositional distribution to have refractive-index 25 distribution at some part, by minute bubbles formed in the resin, or by any dot-like defects at the surface. As for the absorption, it arises from

the molecular structure itself of a resin-constituting substance in some cases, but commonly in many cases it is absorption due to impurities included in the course of synthesis of the resin and a polymerization inhibitor previously added to the resin, or it is absorption due to a 5 photopolymerization initiator and a reaction product thereof, or it is caused by any excess irradiation at the time of curing.

Accordingly, in order to improve light transmittance, it is important to remove impurities by purification as far as possible, taking account of the resin's molecular structure carefully. In addition, it is 10 effective that a composition having a polymerization inhibitor and a photopolymerization initiator in an optimum state is polymerized under proper conditions for the irradiation.

In consideration of the foregoing, the resin layer may have an inner transmittance of 95% or more in a 100 μm thick area, where a PAG lens 15 having optical characteristics good for practical use can be obtained.

In the step of transferring the shape of aspherical surface of a mold by the use of a photosensitive resin, the resin surface may peel from the mold during the irradiation. Such a problem may often occur. It has been ascertained that this relates closely to the rate of shrinkage on 20 curing of resin. The fact that the shape of the mold can not exactly be transferred when a photosensitive resin is used is due to the shrinkage on curing when the resin cures. This shrinkage has a remarkable influence in the case of a PAG lens having a great difference in the extent of aspherical surface or the resin layer thickness. Here, the rate of 25 shrinkage on curing is the value that depends substantially on the composition of the resin, and is an important property which determines

the moldability of resin in the molding for PAG lenses.

Resin layers of PAG lenses have a difference of hundreds of micrometers or more between the maximum layer thickness and the minimum layer thickness. This difference in layer thickness of resin 5 layers has a tendency of becoming larger and larger with a spread of the use of aspheric lenses hereafter. When a resin layer having such a complicated shape is irradiated by light, a stress is produced upon any abrupt shrinkage on curing to cause a difficulty that the shape of the mold is not exactly transferred. The rate of shrinkage on curing can 10 readily be determined by measuring the specific gravity of the resin before and after its curing. More specifically, where the specific gravity before curing is represented by a, and the specific gravity after curing by b, the rate of shrinkage on curing can be calculated according to

$$\{(b-a)/b\} \times 100 (\%).$$

15 Accordingly, resins having different rates of shrinkage on curing have been compared and studied to examine in detail the relationship between the rate of shrinkage on curing and the frequency of occurrence of faulty shape transfer for each resin. As the result, it has been ascertained that a resin having a rate of shrinkage on curing of 7% or less 20 can be molded after the shape of aspherical surface without any problem. The use of such a resin enables production of aspheric lenses in a better moldability and in a superior production efficiency.

In order to control the rate of shrinkage on curing of the resin in this way, it is effective not to make up the resin from monomers, but to 25 add also an oligomer having a relatively large molecular weight so that the number of functional groups per unit weight can be made small.

It has also been found that the problem of weatherability correlates with the rate of moisture absorption of resin. Resin commonly has a higher rate of moisture absorption and also a lower heat resistance than glass, and hence the former is inferior to the latter in respect of the 5 weatherability. Accordingly, the optical performance of PAG lenses has been followed up throughout a year to reveal that it varies seasonably. It has been ascertained that this is caused by the moisture absorption of resin according to changes in moisture in environment. In an environment of high humidity, the resin absorbs moisture to cause a 10 volumetric change, so that the optical performance may deteriorate.

Accordingly, resins having different rates of moisture absorption have been compared and studied to determine resin characteristics which are tolerable in practical use. As the result, it has been discovered that the problem on the changes in humidity can be solved when the rate of 15 hygroscopic change in layer thickness is controlled to be 0.4% or less. This enables production of an aspheric lens having a durability strong enough to be usable even in service environment which changes greatly. Also, in order to make the resin have a low rate of moisture absorption, it is effective to lower the content of hydrophilic groups such as 20 alkyleneoxy and isocyanate groups in the molecule.

As a result of evaluation on the weatherability of various resins, it has also been found that the resin layer may have a greatly poor weatherability when the resin has a low degree of polymerization, and must be cured at a high rate in order to achieve superior weatherability. 25 Accordingly, as an index of the degree of polymerization, gel percentage has been measured which is determined from the weight ratio of

dissolved things of cured resin having been treated with a solvent under stated conditions. As the result, it has been ascertained that a weatherability having no problem in practical use can be achieved when this gel percentage is 95% or more, and particularly preferably 96% or 5 more.

The gel percentage is determined from a change in weight observed when the component having dissolved in the solvent under stated conditions is removed. Stated in detail, it is measured under the following conditions.

10 That is, about 0.5 g of a resin cured product is dried in a desiccator for about a day, and thereafter the mass of the dried resin obtained is precisely measured. Next, this resin is immersed in 70°C methyl ethyl ketone for 6 hours. Here, the methyl ethyl ketone is changed for new one at intervals of 2 hours. The resin having been immersed for 6 hours 15 is heated at 100°C for 2 hours, and then left in the desiccator for a day to make it dry. Thereafter, the mass of the resin thus dried is precisely measured. Here, where the mass of the initial resin is represented by c, and the mass after immersion in methyl ethyl ketone by d, the gel percentage is calculated according to

20
$$(d/c) \times 100 (\%).$$

The cause of deterioration of the weatherability of resin is that unreacted functional groups remain also after the molding. Such unreacted functional groups may cause various side reaction over a long period of time to cause the coloring of resin. In this regard, the resin 25 having a high gel percentage has less unreacted functional groups. Hence, such a resin is considered to have superior weatherability. In

actual use, in order to provide a sufficient weatherability, it is preferable for the resin to have the gel percentage of 95% or more as stated above. In order to make the gel percentage higher, it is effective to optimize the amount of a photopolymerization initiator to be added and the level of 5 irradiation.

There has been an additional problem that conventional resins for PAG lenses have a lower mar resistance than aspheric lenses made of glass, and tend to be marred when handled in, e.g., the step of assembling lenses. It has been discovered that the use of a resin having a durometer 10 hardness of HDD 70 or more makes the resin not become marred in usual handling. The use of such a resin enables production of an aspheric lens having superior mar resistance to make it possible to obtain an aspheric lens durable to its use in service environment which tends to cause mars.

This broadens the scope in which the aspheric lens is applicable. Also, 15 in order to make the resin have such a higher hardness, it is important that the amount of a photopolymerization initiator to be added and the conditions for irradiation are optimized to cure the resin sufficiently. It is also effective to add to components a resin having a hard skeleton such as bisphenol-A skeleton.

20 The surfaces of resin layers of PAG lenses are usually provided with anti-reflection coat. Such a anti-reflection coat is formed by vacuum deposition or the like. If the resin has a low heat resistance, the resin may expand when heated by radiation heat at the time of this film formation, so that a coat layer harder than the resin can not follow up the 25 latter's changes in shape to make the anti-reflection coat have cracks in some cases. Thus, the resin used in PAG lenses is required to have

properties not causative of any changes even at high temperature.

Accordingly, in respect of some resins having different glass transition points, how the resins cause cracks has been compared and studied. As the result, it has been ascertained that a resin having a glass transition temperature of 95°C or above can keep cracks from occurring. Thus, the use of the resin having such a property enables production of an aspheric lens having various durabilities and, in addition thereto, having superior reflection preventive performance and durable to more various service environments. In order to make the glass transition temperature higher, it is effective to use a polyfunctional (meth)acrylate or a polyfunctional urethane (meth)acrylate as a component of the resin. Here, the glass transition temperature can be determined as the point of inflection of a curve showing dimensional changes caused by heating, using TMA (thermomechanical analysis), a type of thermal analysis.

On the basis of the new findings explained above, the present invention provides an optical element comprising a base member and a resin layer formed on the surface of the base member and comprising a cured product of a photosensitive resin composition. The resin layer is a resin layer having at least one characteristic features of the following (1) to (7). The present invention also provides an optical lens comprising this aspheric lens, and provides an optical article having the optical lens. Incidentally, the resin layer in the aspheric lens of the present invention may preferably have at least two of any of these characteristic features.

(1) It has a refractive index of 1.55 or more.

(2) It has a visible-light inner transmittance of 95% or more in a 100 μm thick area.

- (3) It has a rate of hygroscopic dimensional change of 0.4% or less.
- (4) It has a durometer hardness of HDD 70 or more.
- (5) It has a gel percentage of 95% or more.
- (6) It has a glass transition temperature of 95°C or above.
- 5 (7) It has a rate of shrinkage on curing of 7% or less (i.e., it is a cured product of a resin composition having a rate of shrinkage on curing of 7% or less.

In the case when the optical element of the present invention is an aspheric lens, the shape of aspherical surface may be formed on the side 10 of convex surface, or may be formed on the side of concave surface. In other words, the resin layer may be formed on either of concave and convex sides of a base member lens.

2. Resin composition:

Accordingly, studies have been made on resins preferable for 15 satisfying the above characteristics. As the result, what is preferable as the resin layer in the optical element of the present invention has been found to be a resin layer comprising a cured product of a photosensitive resin composition containing:

- (A) a polyfunctional (meth)acrylate;
- 20 (B) a polyfunctional urethane-modified (meth)acrylate; and
- (C) a photopolymerization initiator. The components (A) to (C) may preferably be contained as chief components. Incidentally, in the present specification, an acrylate and a methacrylate are generically termed "(meth)acrylate".

25 The resin composition used in the optical element of the present invention may preferably have a viscosity before polymerization curing,

of 50,000 cP or lower at room temperature. If the resin composition has a viscosity higher than 50,000 cP, it may have a poor operability and also may cause an increase in defectives due to inclusion of bubbles.

In general, resins change in refractive index before and after curing.

5 Hence, in order to attain the desired refractive index after curing, the composition of the resin must be determined taking account of the changes in refractive index before and after curing. Accordingly, in respect of the above resin composition, changes in refractive index before and after curing have been studied in detail. As the result, it has been
10 ascertained that the refractive index after curing comes to 1.55 or more when the refractive index before curing is 1.52 or more. Thus, the photosensitive resin composition in the present invention may preferably have a refractive index before curing of 1.52.

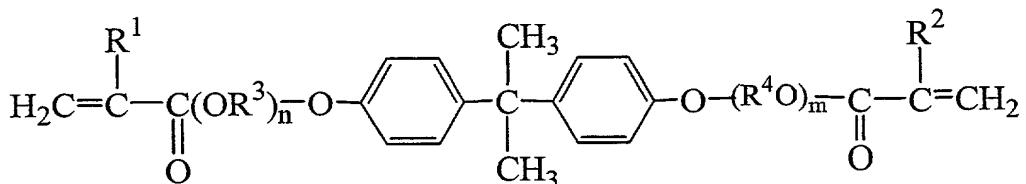
In order for the resin composition to have the refractive index of
15 1.52 or more before curing, the component-(A) polyfunctional (meth)acrylate alone may be made to have a refractive index of 1.53 or more. Such a polyfunctional (meth)acrylate having a refractive index of 1.53 or more may preferably be selected from those having two or more benzene ring structures in one molecule.

20 As specific examples of the polyfunctional (meth)acrylate, it may include bifunctional (meth)acrylates such as di(meth)acrylate of 2,2-dimethyl-3-hydroxypropyl-2,2-dimethyl-3-propionate, ethylene glycol di(meth)acrylate, polyethylene glycol di(meth)acrylate, propylene glycol di(meth)acrylate, polypropylene glycol di(meth)acrylate, 1,4-butanediol
25 di(meth)acrylate, 1,6-hexanediol di(meth)acrylate, neopentyl glycol di(meth)acrylate, di(meth)acrylate of an ethylene oxide addition product

of bisphenol A, di(meth)acrylate of a propylene oxide addition product of bisphenol A, di(meth)acrylate of 2,2'-di(hydroxypropoxyphenyl)propane, di(meth)acrylate of tricyclodecane dimethylol, and a di(meth)acrylic acid addition product of 2,2'-di(glycidyloxyphenyl)propane.

5 It may also include as compounds preferred as the component (A) in the present invention, e.g., trimethylopropane tri(meth)acrylate, pentaerythritol tri(meth)acrylate, pentaerythrythol tetra(meth)acrylate, dipentaerythritol hexa(meth)acrylate, tetramethylolmethane tetra(meth)acrylate, tri(meth)acrylate of tris(hydroxyethyl)isocyanurate, 10 tri(meth)acrylate of tris(2-hydroxyethyl)isocyanurate, tri(meth)acrylate of trimellitic acid, triallyltrimellitic acid, and triallyl isocyanurate.

As a result of extensive studies, the present inventors have discovered that a di(meth)acrylate represented by the following Formula (1) is particularly preferred as the component (A). Of the 15 di(meth)acrylate represented by Formula (1), one having a molecular weight of 1,000 or less is more preferred because of its small refractive index.



20

(1)

wherein R¹ and R² are each a hydrogen atom or a methyl group, R³ and R⁴ are each a hydrocarbon group having 2 to 4 carbon atoms, and m and n are each an integer of 1 or more.

The component (A) may be constituted of one kind of polyfunctional (meth)acrylate, or may be constituted of two kinds or more. This component (A) has the function to enhance the refractive index of the resin used in the optical element of the present invention.

5 Accordingly, the component (A) may preferably have a refractive index before curing of 1.53 or more.

The polyfunctional (meth)acrylate having benzene rings tends to have a large molecular weight. The one having too large a molecular weight may make the resin have too high a viscosity. On the other hand, 10 the resin may have a low viscosity when the structure $(R^3-O)_n$ and/or $(R^4-O)_m$ other than the benzene rings in Formula (1) is/are large, but may also have a low refractive index. Accordingly, polyfunctional (meth)acrylates having various molecular weights have been compared and studied. As the result, it has been ascertained that it is suitable for 15 the molecular weight to be 1,000 or less.

The component (A) may preferably be in a content of from 10 to 95% of the resin as weight percentage. If it is less than 10%, the resin may have a refractive index less than 1.55. If it is more than 95%, the resin may have a low environmental resistance.

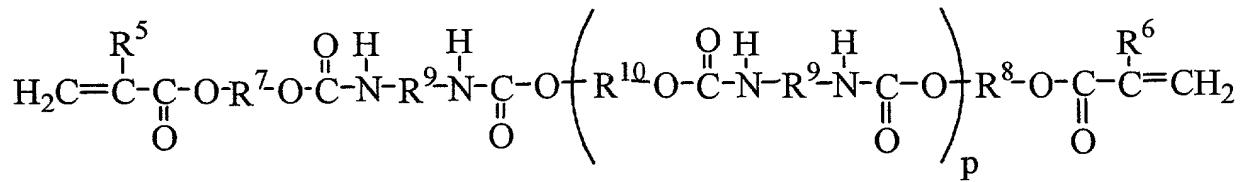
20 The component (B) is a polyfunctional urethane-modified (meth)acrylate. This is a compound composed chiefly of a diisocyanate, a polyol and a hydroxy(meth)acrylate. Also, a polyester diol may optionally be used. The component (B) may be constituted of one kind of polyfunctional urethane-modified (meth)acrylate, or may be 25 constituted of two kinds or more.

The component-(B) polyfunctional urethane-modified

(meth)acrylate commonly has a low refractive index. In order for the resin to have the refractive index of 1.52 or more after mixing, the polyfunctional urethane-modified (meth)acrylate alone may preferably be made to have a refractive index of 1.48 or more. If the component (B) 5 has a refractive index less than 1.48, the resin layer may have a low refractive index.

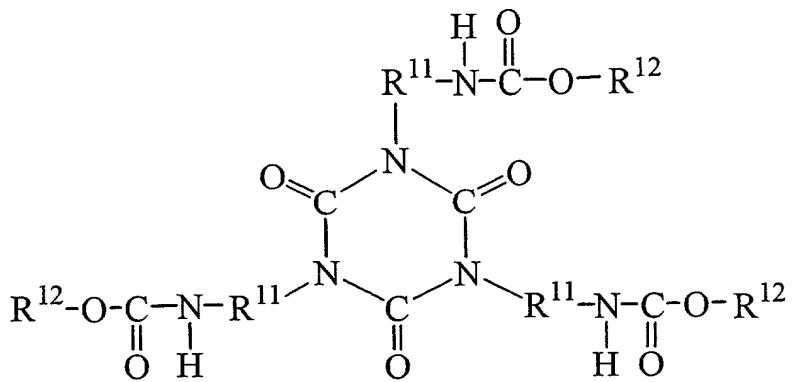
As a result of extensive studies, the present inventors have discovered that a compound represented by any of the following Formulas (2) to (4) is particularly preferred as the component (B).

10



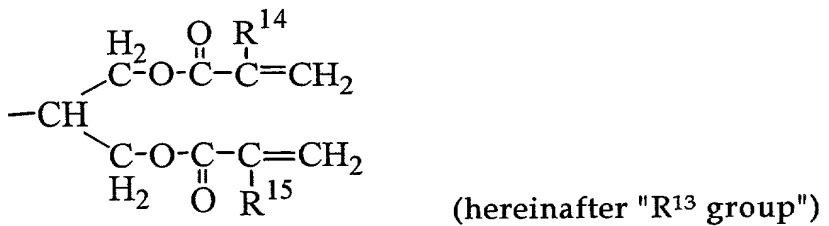
(2)

wherein R⁵ and R⁶ are each a hydrogen atom or a methyl group, R⁷ and R⁸ 15 are each a hydrocarbon group having 1 to 10 carbon atoms, R⁹ is an isocyanate residual group, R¹⁰ is a polyol residual group or a polyester residual group, and p is 0 or an integer of 10 or less.

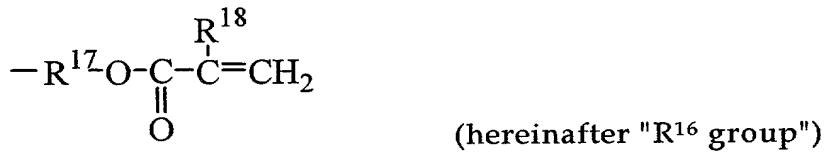


(3)

5 wherein R^{11} is a hydrocarbon group having 1 to 10 carbon atoms, and R^{12} is

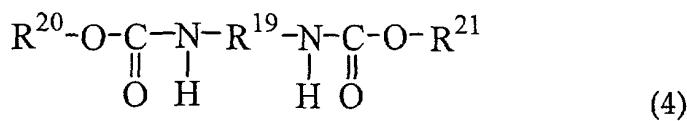


10 or

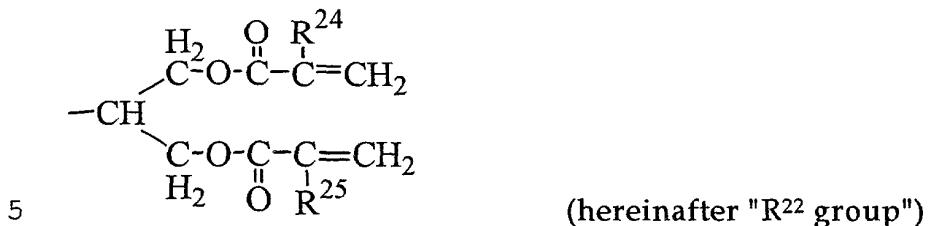


wherein R^{14} , R^{15} and R^{18} are each a hydrogen atom or a methyl group, and R^{17} is a hydrocarbon group having 1 to 10 carbon atoms.

15



wherein R^{19} is a hydrocarbon group having 1 to 10 carbon atoms, and R^{20} and R^{21} are each



or



10 wherein R^{24} , R^{25} and R^{26} are each a hydrogen atom or a methyl group, and R^{27} is a hydrocarbon group having 1 to 10 carbon atoms.

R^9 in Formula (2) may preferably contain an aliphatic ring or an aromatic ring, taking account of the refractive index of the component (B).

Also, as in Formula (3), the (meth)acrylate may be bonded to the

15 isocyanate cyclic trimer. The (meth)acrylate in Formulas (3) and (4) may
be monofunctional or may be polyfunctional.

The component (B) may preferably be in a content of from 5 to 80% of the resin as weight percentage. If it is less than 5%, the resin may

20 may have so high a viscosity as to result in a poor operability.

As the component-(C) photopolymerization initiator, any known compound may be used. For example, substances of an acetophenone type, a benzoin type, a benzophenone type, a thioxane type and an acylphosphine oxide type may be used. In the present invention, as the 5 photopolymerization initiator, any one selected from these may be used, or two or more of these may be used in combination. If necessary, a photopolymerization initiator auxiliary agent may further be added.

The component (C) may preferably be in an amount of from 0.1 to 5% of the resin as weight percentage. As long as it is within this range, 10 the resin can be cured at an appropriate curing rate without any lowering of its properties.

In addition to the components (A) to (C) described above, the photosensitive resin composition used in the present invention may preferably further contain at least one additive selected from:

- 15 (D) a monofunctional (meth)acrylate;
- (E) a release agent;
- (F) a silicon compound; and
- (G) an epoxy (meth)acrylate.

The component-(D) monofunctional (meth)acrylate commonly has a 20 higher fluidity than other components, and hence it flows through the interior of the resin layer also in the course of polymerization reaction caused by irradiation, and has the effect of keeping any internal stress from being produced. Concurrently therewith, it has the effect of lessening unreacted functional groups and making the gel percentage 25 higher to improve the weatherability of the optical element. Hence, the addition of the component (D) enables the mold shape to be transferred

in a higher precision to provide an optical element having a surface with higher precision.

As specific examples of the component (D), it may include methyl (meth)acrylate, ethyl (meth)acrylate, cyclohexyl (meth)acrylate, 5 dicyclopentyl (meth)acrylate, isobornyl (meth)acrylate, bornyl (meth)acrylate, phenyl (meth)acrylate, halogen-substituted phenyl (meth)acrylate, benzyl (meth)acrylate, α -naphthyl (meth)acrylate, β -naphthyl (meth)acrylate, and dicyclopentyloxyethyl acrylate. Any one of these substances may be used alone, or two or more selected from these 10 may be used in combination.

The component (D) may preferably be in an amount of from 0.1 to 30% of the resin as weight percentage. As long as it is within this range, the fluidity of resin at the time of molding can be ensured without any lowering of the properties of the resin.

15 The component-(E) release agent is used in order to weaken the release-resisting force acting when a resin cured product is released from the mold after the resin has been cured upon irradiation. The addition of the component (E) enables the resin to be prevented from sticking to the mold to remain even after a large number of optical elements have 20 been formed, and a much higher figure tolerance can be achieved.

As this component (E), any known materials may be used. As specific examples, it may include neutralizable or non-neutralizable phosphate alcohols. As to the component (E), too, any one of them may be used alone or two or more of them may be used in combination.

25 The component (F) is a silicon compound. It has the effect of smoothing the surface of the cured product to improve the mar resistance

or keep any defects from occurring. Hence, the addition of the component (F) in a very small quantity makes the smoothness of resin surface higher and brings about an improvement in mar resistance, so that an optical element having a much higher durability can be obtained.

5 In the present invention, a wide range of substances are usable as the silicon compound. As specific examples of the compound usable as the component (F), it may include tetramethoxysilane, tetraethoxysilane, γ -methacryloxypropyltrimethoxysilane, γ -glycidyloxypropyltrimethoxysilane, and (meth)acrylates having an Si-O linkage at some part of the backbone chain.

10 The component (F) may preferably be added in an amount of from 0.001% by weight to 10% by weight. Its addition in an amount less than 0.001% by weight can not be effective. Its addition in an amount more than 10% by weight not only may provide no desired refractive index, but 15 also may cause faulty external appearance such as milky-white.

15 The component-(G) epoxy (meth)acrylate provide the resin appropriately with an adhesion attributable to the hydroxyl groups formed upon cleavage of epoxy groups to afford the effect of preventing the resin from coming off from the mold during the irradiation. Hence, 20 the addition of the component-(G) epoxy (meth)acrylate in an appropriate quantity can prevent the resin from coming off from the mold during UV irradiation. This is effective especially when the PAG lens having a large extent of aspherical surface is formed.

25 There are no particular limitations on the epoxy (meth)acrylate to be used. For example, usable are addition reaction products of an epoxy resin such as phenolic novolak epoxy resin, bisphenol-A epoxy resin,

glycerol polyglycidyl ether or 1-6 hexane diglycidyl ether with a monomer having a (meth)acrylic acid or carboxylic acid group.

The component (G) may preferably be added in an amount of from 1% by weight to 30% by weight. Its addition in an amount less than 1% by weight can not be effective. Also, its addition in an amount more than 30% by weight may provide so strong adhesion between the mold and the resin as to make mold release difficult.

3. Exposure step:

In the present invention, the photosensitive resin composition capable of curing upon exposure is used to form the resin layer. In order to improve the weatherability by curing the resin to a higher degree of cure, the energy of light with which the resin is irradiated at the time of curing must be made higher. In conventional cases, the degree of cure is enhanced with an increase in the level of irradiation, but resulting in a decrease in light transmittance. The present inventors have examined the relationship between the light transmittance of a resin and the wavelength of the light applied to cure the resin. As the result, they have discovered that irradiation by light with a wavelength of 300 nm or more can make the light transmittance higher than that in conventional cases even when the level of irradiation is made higher than that in conventional cases to cure the resin to a higher degree.

Accordingly, the present invention provides a process for producing a resin-cemented optical element, the process comprising:

a first exposure step of irradiating a photosensitive resin composition held between the surface of a base member and a mold, by light with a wavelength of 300 nm or more to cure the composition to

form a resin layer; and

a mold release step of mold-releasing the resin layer;
in this order.

The irradiation by such light may also be performed

- 5 at one time, or may be done twice or more. In order to cure the resin to a higher degree, it is effective to irradiate the resin-cemented optical element additionally after mold release. In conventional cases, however, such an additional irradiation has been considered not preferable because an increase in irradiation level may make the degree of cure higher but
- 10 results in a lowering of light transmittance. However, the present inventors have discovered that the additional irradiation after mold release may also be made by light with a wavelength of 300 nm or more and this enables the resin to be further cured to a higher degree than the degree before additional irradiation and at the same time enables the
- 15 resin to be more improved in light transmittance than that before such irradiation.

Accordingly, the present invention provides a process for producing a resin-cemented optical element, the process comprising:

- 20 a first exposure step of irradiating a photosensitive resin composition held between the surface of a base member and a mold, to cure the composition to form a resin layer;
- 25 a mold release step of mold-releasing the resin layer; and
- 25 a second exposure step of irradiating the resin layer by light with a wavelength of 300 nm or more;
- 25 in this order.

To perform this additional irradiation, a method may be employed

in which, e.g., a plurality of resin-cemented optical elements having been released from the mold are put into an exposure unit having a light source which radiates light with a wavelength of 300 nm or more, and irradiate the resin-cemented optical elements additionally at one time.

5 The mechanism is unclear as to the phenomenon that the degree of cure of the resin is improved and the light transmittance of the resin is also improved by setting to 300 nm or more the wavelength of the light to which the resin is exposed. It, however, can be presumed that, probably the light with a wavelength of 300 nm or more accelerates the curing 10 reaction of the resin, without destroying the chemical structure of the resin to cause absorption, and hence the resin is cured to a higher degree and at the same time a reaction initiator contained in the resin is thereby consumed, so that the absorption of light that is inherent in the reaction initiator may less occur.

15 As the light source used to irradiate the photosensitive resin composition by light (usually, ultraviolet light is preferred) to effect exposure to cure the composition, a metal halide lamp, a high-pressure mercury lamp, a low-pressure mercury lamp, a black light, a chemical lamp or the like may be used. Of these, the metal halide lamp, the 20 high-pressure mercury lamp and the chemical lamp are preferred because they can emit light with a wavelength of 300 nm or more in a good efficiency. It is also preferable to shield the light with a wavelength of less than 300 nm by the use of a commercially available filter or the like.

There are no particular limitations on the atmosphere of exposure. 25 The exposure may be performed in air, in an atmosphere of nitrogen, in an atmosphere of an inert gas or in vacuum, depending on the properties

of the photosensitive resin composition to be used.

At the time of the exposure, the resin composition may also be heated in order to accelerate its curing. When heated, it may preferably be heated at a temperature of from 40°C to 130°C. At a temperature 5 lower than 40°C, any sufficient effect is not obtainable in some cases. At a temperature higher than 130°C, the resin may become too soft to retain the desired shape of the resin layer.

In the present invention, when the irradiation is performed a plurality of times, the same light source may be used, or a different light 10 source may be used each time. Also, its atmosphere may be so changed such that the first irradiation is performed in air and the second and subsequent irradiation in an atmosphere of nitrogen.

The base member surface may also previously be subjected to coupling treatment with a coupling agent so that the resin layer can be 15 made to adhere strongly to the base member.

4. Heating step:

In the present invention, the step of heating the resin composition or resin cured product may preferably be provided in the steps for producing the resin-cemented optical element. This enables more 20 improvement of the light transmittance of the resin than that in conventional cases, and also enables the resin to be cured to a higher degree to improve the weatherability.

This heating may be carried out at any time, and may preferably be carried out after the resin composition has been photo-cured and the 25 cured product has been released from the mold together with the base member. For example, a plurality of resin-cemented optical elements

having been released from the mold may be put into an oven in one lot and heated at one time, thus the heating can be carried out in a good productivity and at a low cost.

Accordingly, the present invention provides;

5 (1) a process for producing a resin-cemented optical element, the process comprising:

an exposure step of irradiating a photosensitive resin composition held between the surface of a base member and a mold, to cure the composition to form a resin layer;

10 a mold release step of mold-releasing the resin layer; and
a heating step of heating the resin layer;

in this order; and

(2) a process for producing a resin-cemented optical element, the process comprising:

15 an exposure step of irradiating a photosensitive resin composition held between the surface of a base member and a mold, with heating to cure the composition to form a resin layer; and
a mold release step of mold-releasing the resin layer;

in this order.

20 Incidentally, the mechanism is unclear as to the phenomenon that the light transmittance and degree of cure of the resin are improved by the heating. It, however, can be presumed that, the heating accelerates the post-curing (a phenomenon that the curing of photosensitive resin proceeds gradually also after exposure) of the resin to enhance the degree 25 of cure, and also, since in the heating step the curing reaction proceeds without the exposure, the chemical structure of the resin is not destroyed

by light and on the contrary any slight absorption sources caused in the resin layer at the time of curing are remedied on.

In this heating step, the heating temperature may preferably be from 40°C to 130°C. At a temperature lower than 40°C, any sufficient 5 effect is not obtainable in some cases. At a temperature higher than 130°C, the resin may become too soft to retain the desired shape of the resin layer.

Between the mold release step and the heating step, the second exposure step described previously may also be provided in order to 10 accelerate the curing reaction further and improve the inner transmittance.

5. Others:

The resin-cemented optical element of the present invention may include, e.g., lenses, prisms and diffraction gratings. The present 15 invention can well be effective especially when applied to aspheric lenses, and is especially suited for still cameras such as an analog still camera and a digital still camera, and video cameras, or interchangeable lenses for these, which are used in various environments and whose optical systems are especially required to be made compact and light-weight and 20 to have good optical characteristics.

As materials of the base member in the present invention, any of glass, plastic and so forth may appropriately be selected as long as they do not deform or change in properties as a result of the heating in the heating step.

Fig. 1 is a schematic illustration of a PAG lens according to the present invention.

Fig. 2 is a schematic illustration of the step of feeding a resin composition in a PAG lens production process.

5 Fig. 3 is a schematic illustration of an exposure step in the PAG lens production process.

Fig. 4 is a schematic illustration of a heating step in the PAG lens production process.

10 Fig. 5 is a schematic illustration of an exposure step in a PAG lens production process.

BEST MODES FOR PRACTICING THE INVENTION

The present invention is specifically described below by giving Examples. The present invention is by no means limited to these 15 Examples.

In the following Examples, the resin layer is irradiated by light (ultraviolet light) on the side of the base member, and a metal mold made of a metal is used as the mold. In the present invention, however, the mold is by no means limited to it. For example, a mold comprised of a 20 transparent material such as glass may also be used as the mold. When such a transparent material is used as the mold, the resin composition can be cured by irradiation on the side of the mold, and hence the base member need not be transparent. On the other hand, when an opaque material such as a metal is used as the mold as in the following Examples, 25 a light-transmissive material must be used as the base member because it is necessary to irradiate the photosensitive resin composition on the side

of the base member. Accordingly, in the following Examples, a glass lens is used as the base member.

In the following Examples, the value at a wavelength of 380 nm was used as the inner transmittance, where the order of fluctuations of 5 the inner transmittance value did not reverse.

Example 1

In this Example, first a resin composition (photosensitive resin composition) was prepared which was obtained by mixing the following components (A) to (C). Next, this composition was coated on a glass 10 base, followed by curing to form a resin layer to produce a PAG lens.

Component (A): 80 parts of di(meth)acrylate of Formula (1) wherein $m + n$ is 3.

Component (B): 19.5 parts of urethane-modified di(meth)acrylate of Formula (2).

15 Component (C): 0.5 part of an acetophenone type photopolymerization initiator.

The refractive index of this resin composition before curing was 1.535, and the viscosity thereof at room temperature was 3,500 cP.

This resin composition was poured into a base mold made of glass, 20 and then irradiated by light of a high-pressure mercury lamp for 2 minutes to form a rectangular colorless transparent block of 2 mm thick. Concerning this block, its refractive index after curing was measured to find that it was 1.556. Its durometer hardness was also measured to find that it was HDD 78.

25 Its inner transmittance in a 100 μm thick area was further calculated using data of spectral transmittance of a molded product

different in thickness to reveal that the transmittance was 97% for the light with a wavelength of 380 nm.

Next, the glass transition temperature Tg was examined on a molded product of 2 mm thick. The Tg was determined as the point of 5 inflection of a curve showing dimensional changes caused by heating, using TMA (thermomechanical analysis), a type of thermal analysis. As the result, the Tg was 97°C.

Next, using a molded product of 2 mm thick, the rate of hygroscopic dimensional change before and after moisture absorption 10 was examined. More specifically, the initial dimension of the molded product was measured in an environment of 25°C/50% RH, and thereafter put into a thermo-hygrostat for 24 hours which was kept at 50°C/90% RH, to cause the molded product to absorb moisture. Thereafter, its dimensions were measured again in the environment of 25°C/50% RH to 15 determine their change rate. As the result, the rate of hygroscopic dimensional change was 0.35%.

The gel percentage was determined in the following way: About 0.5 g of the resin cured product was dried in a desiccator for about a day, and thereafter the mass of the dried resin obtained was precisely 20 measured. Next, this resin was immersed in 70°C methyl ethyl ketone for 6 hours. Here, the methyl ethyl ketone was changed for new one at intervals of 2 hours. The resin having been immersed for 6 hours was heated at 100°C for 2 hours, and then left in the desiccator for a day to make it dry. Thereafter, the mass of the resin thus dried was precisely 25 measured. Here, where the mass of the initial resin was represented by c, and the mass after immersion in methyl ethyl ketone by d, the gel

percentage was calculated to be 97% according to the expression: $(d/c) \times 100 (\%)$.

The rate of shrinkage on curing was calculated using measurements of specific gravity before and after curing. As the result, the rate of 5 shrinkage on curing was 5.5%.

In this Example, a PAG lens was produced in the following way. First, as shown in Fig. 2, a resin composition 21 was dropped on the concave surface of a glass base member 10. As shown in Fig. 3, the glass base member 10 on which the resin composition was dropped was, with 10 its upside down, pressed against a convex aspherical-surface metal mold 32 to press and spread the resin composition 21 into the desired shape. Thereafter, the resin composition was irradiated by ultraviolet rays 33 for 2 minutes by means of a high-pressure mercury lamp (not shown) to cure the resin composition 21. After the resin composition 21 was cured, the 15 cured product was released from the mold to obtain a PAG lens 12 as shown in Fig. 1, comprising the glass base member 10 having on its surface a resin layer 11.

Here, the glass base member 10 used in this Example was 40 mm in diameter, and its side on which the resin was to be dropped was 20 previously subjected to silane coupling treatment to improve the adhesion of glass to the resin layer 11.

The resin layer of the PAG lens 12 obtained in this Example has a greatly aspherical shape in a maximum thickness of 800 μm and a minimum thickness of 100 μm . Even though the resin layer was molded 25 in such a greatly aspherical shape, the desired aspherical shape stood transferred exactly to the resin layer without any coming-off of the resin

from the metal mold during the molding.

On the PAG lens thus obtained, a anti-reflection coat (not shown) was formed by vacuum deposition. As the result, a PAG lens having both good external appearance and good performance was producible 5 without causing any difficulties such as cracking. A heat resistance test was made on the PAG lens having this anti-reflection coat. As the result, even though it was left in an environment of 70°C for 24 hours, any change in external appearance was not seen at all.

A weatherability test was also made using a carbon fadometer. 10 The change in transmittance at 380 nm after the weatherability test was 0.5% or less in terms of the inner transmittance in a 100 µm thick area. This is value not problematic at all in practical use.

Example 2

In this Example, a PAG lens was produced in the same manner as 15 in Example 1 except that the urethane-modified hexa(meth)acrylate of Formula (3) was used as the component (B) of the resin composition.

Physical properties of the resin composition before curing and of the resin after curing which were measured in the same manner as in Example 1 are shown in Table 1.

Table 1

		Example						
		1	2	3	4	5	6	7
Before curing:	Refractive index	1.535	1.531	1.532	1.525	1.529	1.529	1.530
	Viscosity at room temperature (cP)	3500	4500	2000	3000	3500	3500	3500
After curing:	Refractive index	1.556	1.552	1.556	1.551	1.555	1.555	1.556
	Durometer hardness	HDD78	HDD82	HDD80	HDD80	HDD79	HDD79	HDD80
	Transmittance (100 µm thickness)	97	98	98	98	98	98	98
	Glass transition temperature (°C)	97	101	100	99	100	100	100
	Hygroscopic dimensional change (%)	0.35	0.30	0.35	0.30	0.35	0.35	0.35
	Gel percentage (%)	97	98	98	98	98	98	98
	Shrinkage on curing (%)	5.5	6.0	6.0	5.0	6.0	6.0	6.0

Next, a PAG lens was produced using an aspherical-surface metal

5 mold in the same manner as in Example 1. As the result, the desired aspherical shape stood transferred exactly to the resin layer without any coming-off of the resin from the mold during the molding.

On the surface of the resin layer of the PAG lens thus obtained, a anti-reflection coat was further formed by vacuum deposition. As the 10 result, a PAG lens having both good external appearance and good

performance was producible without causing any difficulties such as cracking in the anti-reflection coat. A heat resistance test was made on the PAG lens having this anti-reflection coat. As the result, even though it was left in an environment of 70°C for 24 hours, any change in external 5 appearance was not seen at all.

The same good results as those in Example 1 were also obtained in the weatherability test made using a carbon fadometer.

Example 3

In this Example, a PAG lens was produced in the same manner as 10 in Example 1 except that the urethane-modified tetra(meth)acrylate of Formula (4) was used as the component (B) of the resin composition. As the result, the desired aspherical shape had exactly been transferred to the resin layer without any coming-off of the resin from the mold during the molding. Physical properties of the resin composition before curing 15 and of the resin after curing which were measured in the same manner as in Example 1 were as shown in Table 1.

On the surface of the resin layer thus obtained, a anti-reflection coat was further formed in the same manner as in Example 1. As the result, a PAG lens having both good external appearance and good 20 performance was obtained, and the results of its heat resistance test were also as good as those in Example 1.

The same good results as those in Example 1 were also obtained in the weatherability test made using a carbon fadometer.

Example 4

25 In this Example, a resin composition was prepared by mixing as the component (A) 80 parts of the di(meth)acrylate of Formula (1), as the

component (B) 14.5 parts of the urethane-modified di(meth)acrylate of Formula (2), as the component (C) 0.5 part of an acetophenone type photopolymerization initiator and as the component (D) 5 parts of methyl(meth)acrylate. Using this composition, a PAG lens was 5 produced. As the result, the desired aspherical shape had exactly been transferred without any coming-off of the resin from the metal mold during the molding. Physical properties of the resin composition before curing and of the resin after curing which were measured in the same manner as in Example 1 were as shown in Table 1.

10 On the surface of the resin layer thus obtained, a anti-reflection coat was further formed in the same manner as in Example 1. As the result, a PAG lens having both good external appearance and good performance was obtained, and the results of its heat resistance test were also as good as those in Example 1.

15 The same good results as those in Example 1 were also obtained in the weatherability test made using a carbon fadometer.

Example 5

In this Example, a photosensitive resin composition was prepared by mixing as the component (A) 80 parts of the di(meth)acrylate of 20 Formula (1), as the component (B) 19 parts of the urethane-modified di(meth)acrylate of Formula (2), as the component (C) 0.5 part of an acetophenone type photopolymerization initiator and as the component (E) 0.5 part of a non-neutralizable phosphate alcohol. Using this composition, a PAG lens was produced. As the result, the desired 25 aspherical shape had exactly been transferred without any coming-off of the resin from the metal mold during the molding.

In particular, when the resin of this Example was used, much better releasability than that in Examples 1 to 4 was achievable, and the resin did not adhere to the mold even when a large number of PAG lenses were continuously formed. As the result, the time taken for cleaning the mold 5 was reduced to half or less, bringing about an improvement in production efficiency.

Physical properties of the resin composition before curing and of the resin after curing which were measured in the same manner as in Example 1 were as shown in Table 1.

10 On the surface of the resin layer of the PAG lens thus obtained, a anti-reflection coat was further formed in the same manner as in Example 1. As the result, like Example 1, a PAG lens having both good external appearance and good performance was obtained, and the results of its heat resistance test were also as good as those in Example 1.

15 The same good results as those in Example 1 were also obtained in the weatherability test made using a carbon fadometer.

Example 6

In this Example, a photosensitive resin composition was prepared by mixing as the component (A) 80 parts of the di(meth)acrylate of 20 Formula (1), as the component (B) 19 parts of the urethane-modified di(meth)acrylate of Formula (2), as the component (C) 0.5 part of an acetophenone type photopolymerization initiator and as the component (F) 0.5 part of γ -methacryloxypropyltrimethoxysilane. Using this composition, a PAG lens was produced. As the result, the desired 25 aspherical shape had exactly been transferred without any coming-off of the resin from the metal mold during the molding. As a result of

microscopic observation of the resin surface of the PAG lens of this Example, the surface was found to be very smooth. Also, though in the PAG lenses of Examples 1 to 5 microscopic defects of few μm or less in diameter were slightly present at their surfaces, such defects were not 5 seen at all in the PAG lens of this Example.

Physical properties of the resin composition before curing and of the resin after curing which were measured in the same manner as in Example 1 were as shown in Table 1.

On the surface of the resin layer thus obtained, a anti-reflection 10 coat was further formed in the same manner as in Example 1. As the result, like Example 1, a PAG lens having both good external appearance and good performance was obtained, and the results of its heat resistance test were also as good as those in Example 1.

The same good results as those in Example 1 were also obtained in 15 the weatherability test made using a carbon fadometer.

Example 7

In this Example, a photosensitive resin composition was prepared by mixing as the component (A) 70 parts of the di(meth)acrylate of Formula (1), as the component (B) 19 parts of the urethane-modified 20 di(meth)acrylate of Formula (2), as the component (C) 0.5 part of an acetophenone type photopolymerization initiator and as the component (G) 10.5 parts of bisphenol-A epoxyacrylate. Using this composition, a PAG lens was produced. As the result, the desired aspherical shape had exactly been transferred without any coming-off of the resin from the 25 metal mold during the molding. Physical properties of the resin composition before curing and of the resin after curing which were

measured in the same manner as in Example 1 were as shown in Table 1.

It was also tested to form fifty PAG lenses continuously by using an aspherical-surface metal mold having a difference of as large as 900 μm between the maximum resin thickness and the minimum resin 5 thickness. As the result, any faulty molding did not occur at all. Then, the like test was made using the resins of Examples 1 to 6. As the result, the lenses produced using the resins of Examples 1 to 6 were on the level of no problem in practical use, but faulty molding that the resin came off from the mold during the irradiation by ultraviolet light occurred at a 10 rate of one or two lenses in the fifty lenses for each Example. Thus, the resin of this Example was found to be especially superior.

Physical properties of the resin composition before curing and of the resin after curing which were measured in the same manner as in Example were as shown in Table 1.

15 On the surface of the resin layer thus obtained, a anti-reflection coat was further formed in the same manner as in Example 1. As the result, like Example 1, a PAG lens having both good external appearance and good performance was obtained, and the results of its heat resistance test were also as good as those in Example 1.

20 The same good results as those in Example 1 were also obtained in the weatherability test made using a carbon fadometer.

Example 8

In this Example, a PAG lens was produced using the same photosensitive resin composition as that in Example 1 and using a glass 25 lens of 40 mm in diameter as the base member.

More specifically, the same photosensitive resin composition 21 as

that in Example 1 was dropped on the concave surface of a glass base member 10 subjected previously to silane coupling treatment to improve its adhesion to the resin. The glass base member 10 was, with its upside down, pressed against a convex aspherical-surface metal mold 32 to press 5 and spread the resin composition 21 into the desired shape. Thereafter, the resin composition was irradiated by ultraviolet rays 33 by means of a high-pressure mercury lamp (not shown) to cure the resin composition 21, and the cured product was released from the mold 32 to obtain a PAG lens.

10 At the time of the exposure, the irradiation light was measured with an illuminance meter manufactured by EYEGRAPHICS CO LTD., having the sensitivity center at 365 nm, to find that the irradiation energy was 1,800 mJ/cm². Also, at the time of the exposure, as shown in Fig. 4, irradiation by infrared light 41 was performed through the glass base 15 member 10 by means of an infrared lamp to heat the whole of the resin composition 21 and the mold 32 to 60°C.

The PAG lens thus obtained had the same good optical characteristics and weatherability as those in Example 1. Also, a plurality of PAG lenses having resin layers in different thickness were 20 produced in the same manner as in this Example, and their spectral transmittances were measured. From the measurements obtained, the 100 μm thick inner transmittance was calculated to find that it was 98%. Also, the gel percentage of a resin cured product obtained by curing the resin composition in the same manner as in this Example was determined 25 in the same manner as in Example 1 to find that it was 98%. The results are shown in Table 2.

As can be seen from these results, the introduction of the heating step into the resin-cemented optical element production steps can bring about an improvement in light transmittance of the resin layer and also an improvement in its gel percentage.

5

Table 2

			Exaple 8	Exaple 9	Exaple 10	Exaple 11	
Exposure step:	The first time (before mold release):	Wavelength of irradiation light	not selected	not selected	300nm or more	not selected	
		Irradiation light energy (mJ/cm ²)	1800	1800	3000	1800	
		Heating at the time of exposure	yes	no	no	no	
	The second time (after mold release):	Wavelength of irradiation light	undone	undone	undone	300nm or more	
		Irradiation light energy (mJ/cm ²)				3000	
		Heating at the time of exposure				no	
Heating step:		Heating after curing	no	yes	no	no	
Inner transmittance (%):			98	98	98	98	
Gel percentage (%):			98	98	98	98	

Example 9

A PAG lens was produced in the same manner as in Example 8
 10 except that in this Example the resin composition was not heated at the time of exposure and, after the cured product was released from the metal mold, it was put into an oven and heated at 70°C for 24 hours.

The PAG lens thus obtained had the same good optical

characteristics and weatherability as those in Example 8. Also, the inner transmittance and gel percentage determined in the same manner as in Example 8 in respect of the PAG lens and resin cured product in this Example were both 98%. The results are shown in Table 2.

5 Example 10

A PAG lens was produced in the same manner as in Example 8 except that in this Example the resin composition was not heated at the time of exposure and, at the time of the exposure, as shown in Fig. 5 an ultraviolet-transmitting filter "UV-32" (51), manufactured by HOYA 10 Corporation, was fitted to a high-pressure mercury lamp (not shown) to shut out light 54 with a wavelength of less than 300 among light 52 from the light source so that only light 53 with a wavelength of 300 nm or more was applied as irradiation light 55. This irradiation light 55 was measured in the same manner as in Example 8 to find that the irradiation 15 energy was 3,000 mJ/cm².

The PAG lens thus obtained had the same good optical characteristics and weatherability as those in Example 8. Also, the inner transmittance and gel percentage determined in the same manner as in Example 8 in respect of the PAG lens and resin cured product in this 20 Example were both 98%. The results are shown in Table 2.

As can be seen from these results, the irradiation by light with a wavelength of 300 nm or more at the time of the curing of the resin layer can make the gel percentage of the resin layer higher and also can improve the light transmittance of the resin layer, even under the 25 irradiation at a higher energy than that in conventional cases.

Example 11

A PAG lens was produced in the same manner as in Example 8 except that in this Example the resin composition was not heated at the time of exposure and, after the cured product was released from the metal mold, it was put into a large-sized ultraviolet irradiation unit to 5 further perform additional irradiation by means of a high-pressure mercury lamp to make second-time exposure treatment. At the time of this additional irradiation, an ultraviolet-transmitting filter UV-32, manufactured by HOYA Corporation, was fitted to the high-pressure mercury lamp so that only the light with a wavelength of 300 nm or more 10 was applied. The irradiation light in this additional irradiation was measured with an illuminance meter manufactured by EYEGRAPNICS CO., LTD., having the sensitivity center at 365 nm, to find that the irradiation energy was 3,000 mJ/cm².

The PAG lens thus obtained had the same good optical 15 characteristics and weatherability as those in Example 8. Also, the inner transmittance and gel percentage determined in the same manner as in Example 8 in respect of the PAG lens and resin cured product in this Example were both 98%. The results are shown in Table 2.

As can be seen from these results, the additional irradiation by 20 light with a wavelength of 300 nm or more after the mold release can improve the light transmittance of the resin layer and also can make its gel percentage higher.

Example 12

A PAG lens was produced in the same manner as in Example 11 except that in this Example, at the time of the first-time exposure, too, the 25 ultraviolet-transmitting filter 51 was fitted to the high-pressure mercury

lamp (not shown) in the same manner as in Example 10 to filter the irradiation light 55 so that only the light 53 with a wavelength of 300 nm or more was applied. This irradiation light was measured in the same manner as in Example 8 to find that the irradiation energy was 1,800
5 mJ/cm².

The PAG lens thus obtained had the same good optical characteristics and weatherability as those in Example 8. Also, the inner transmittance and gel percentage determined in the same manner as in Example 8 in respect of the PAG lens and resin cured product in this
10 Example were both 98%. The results are shown in Table 3.

As can be seen from these results, the irradiation by light with a wavelength of 300 nm or more at the time of the curing of the resin layer and the additional irradiation by light with a wavelength of 300 nm or more after the mold release can improve the light transmittance of the
15 resin layer and also can make its gel percentage higher.

Table 3

			Exaple 12	Exaple 13	Exaple 14	
Exposure step:	The first time (before mold release):	Wavelength of irradiation light	300nm or more	300nm or more	not selected	
		Irradiation light energy (mJ/cm ²)	1800	1800	1800	
		Heating at the time of exposure	no	no	no	
	The second time (after mold release):	Wavelength of irradiation light	300nm or more	300nm or more	not selected	
		Irradiation light energy (mJ/cm ²)	3000	3000	3000	
		Heating at the time of exposure	no	no	no	
Heating step:		Heating after curing	no	yes	no	
Inner transmittance (%):			98	98	91	
Gel percentage (%):			98	98	98	

Example 13

5 A PAG lens was produced in the same manner as in Example 12 except that in this Example, after the second-time exposure, the cured product was put into an oven and heated at 70°C for 24 hours.

10 The PAG lens thus obtained had the same good optical characteristics and weatherability as those in Example 8. Also, the inner transmittance and gel percentage determined in the same manner as in Example 8 in respect of the PAG lens and resin cured product in this Example were both 98%. The results are shown in Table 3.

As can be seen from these results, the introduction of the heating

step in the resin-cemented optical element production steps, the irradiation by light with a wavelength of 300 nm or more at the time of the curing of the resin layer and the additional irradiation by light with a wavelength of 300 nm or more after the mold release can improve the 5 light transmittance of the resin layer and also can make its gel percentage higher.

Example 14

A PAG lens was produced in the same manner as in Example 11 except that in this Example, after the second-time exposure, too, the 10 wavelength of the irradiation light was not selected without fitting any ultraviolet-transmitting filter 51 to the high-pressure mercury lamp (not shown).

The PAG lens thus obtained had optical characteristics and weatherability of no problem in practical use like those in Example 8. 15 Also, the inner transmittance and gel percentage determined in the same manner as in Example 8 in respect of the PAG lens and resin cured product in this Example were as shown in Table 3. In this Example, the gel percentage of the resin layer was 98%, which did not differ from the result in Example 11, but the inner transmittance was as low as 91% 20 because the light for the additional irradiation made after mold release comprised the light with a wavelength of less than 300 nm.

POSSIBILITY OF INDUSTRIAL APPLICATION

According to the production process of the present invention, a 25 resin-cemented optical element can be provided which has a resin layer having a high light transmittance and also has superior weatherability.

Hence, the optical characteristics and reliability of the resin-cemented optical element can be improved. This enables resin-cemented optical elements to be mounted on one optical system in a larger number than ever.

5 In the optical element of present invention, the resin used in the resin layer also has a refractive index of 1.55 or more after curing, and hence the light by no means reflect greatly at the interface between the base member and the resin layer even when the base member has a high refractive index. Hence, an optical element having superior optical
10 characteristics in respect of interference fringes can be obtained. Also, since the resin layer has a refractive index of 1.55 or more, the resin layer may be formed in a smaller thickness than a case in which resins having low refractive index are used as in conventional cases. Hence, according to the present invention, an optical element having better optical
15 performance than that in conventional cases can be obtained with ease.

According to the present invention, since for example the transmittance has been improved, a light optical element can be obtained.

Thus, the application of the present invention to the PAG lens enables formation of sharp images which have been difficult for conventional
20 lenses to form.

According to the present invention, since the resin layer can also be formed in a small thickness and the difference between the maximum layer thickness value and minimum layer thickness value can be made small, the moldability for resin-cemented optical elements can be
25 improved. Hence, it can be made to cause less defectives, bringing about an improvement in production efficiency.

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In the present invention, since the resin layer of the resin-cemented optical element can be formed in a smaller thickness than conventional ones and in addition thereto the resin having a low moisture absorption is used, the shape of the resin may less change with time even in an 5 environment of high humidity, and hence an optical element can be obtained which can maintain high performance over a long period of time.

Since also a higher refractive index than conventional one can be achieved when the present invention is applied to PAG lenses, the 10 number of lenses of a lens group consisting of a plurality of lenses in combination can be made smaller. This enables production of light-weight optical articles and achievement of cost reduction.

Moreover, since the resin used in the resin layer in the optical element of the present invention has a higher light transmittance than 15 those conventionally used, and also has a small rate of hygroscopic dimensional change, a high gel percentage, a high glass transition temperature and a small rate of shrinkage on curing, the PAG lens having a large extent of aspherical surface which has ever been impossible to mold can be molded with ease.

20 Moreover, on account of the characteristics such as light transmittance, moisture absorption and rate of shrinkage on curing, an optical element can be produced which has superior optical performance even when the resin layer has a large thickness.

Furthermore, according to the present invention, an optical element 25 also having superior environmental properties can be provided because of the use of the resin having glass transition temperature at the specific

value.

In view of the foregoing, the optical element of the present invention is especially suited for still cameras such as an analog still camera and a digital still camera, and video cameras, or interchangeable lenses for these, which are used in various environments and whose optical systems are especially required to be made compact and light-weight and to have good optical characteristics.

WHAT IS CLAIMED IS:

1 1. An optical element comprising
2 a base member; and
3 a resin layer formed on the surface of the base member and
4 comprising a cured product of a photosensitive resin composition,
5 wherein said resin layer has a refractive index of 1.55 or more.

1 2. An optical element comprising
2 a base member; and
3 a resin layer formed on the surface of the base member and
4 comprising a cured product of a photosensitive resin composition,
5 wherein said resin layer has a visible-light inner transmittance of
6 95% or more in a 100 μm thick area.

1 3. An optical element comprising
2 a base member; and
3 a resin layer formed on the surface of the base member and
4 comprising a cured product of a photosensitive resin composition,
5 wherein said resin layer has a rate of hygroscopic dimensional
6 change of 0.4% or less.

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1 4. An optical element comprising
2 a base member; and
3 a resin layer formed on the surface of the base member and
4 comprising a cured product of a photosensitive resin composition,
5 wherein said resin layer has a durometer hardness of HDD 70 or
6 more.

1 5. An optical element comprising
2 a base member; and
3 a resin layer formed on the surface of the base member and
4 comprising a cured product of a photosensitive resin composition,
5 wherein said resin layer has a gel percentage of 95% or more.

1 6. An optical element comprising
2 a base member; and
3 a resin layer formed on the surface of the base member and
4 comprising a cured product of a photosensitive resin composition,
5 wherein said resin layer has a glass transition temperature of 95°C or
6 above.

1 7. An optical element comprising
2 a base member; and
3 a resin layer formed on the surface of the base member and
4 comprising a cured product of a photosensitive resin composition,

5 wherein said photosensitive resin composition has a rate of shrinkage
6 on curing of 7% or less.

1 8. The optical element according to any one of claims 1 to 7,
2 wherein said resin composition comprises:
3 (A) a polyfunctional (meth)acrylate;
4 (B) a polyfunctional urethane-modified (meth)acrylate; and
5 (C) a photopolymerization initiator.

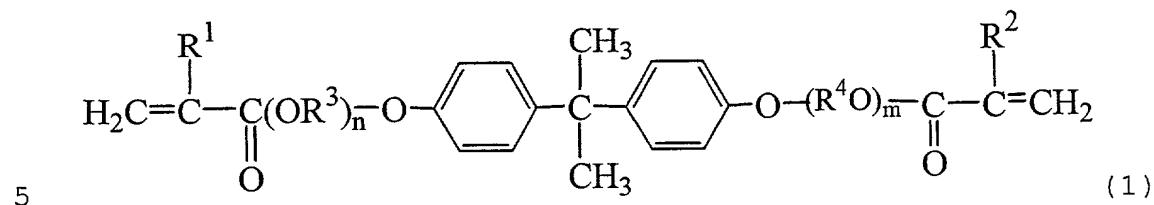
1 9. The optical element according to any one of claims 1 to 8,
2 wherein said resin composition has a refractive index before
3 polymerization curing of, 1.52 or more.

1 10. The optical element according to claim 8, wherein said
2 polyfunctional (meth)acrylate has a refractive index before
3 polymerization curing, of 1.53 or more.

1 11. The optical element according to any one of claims 8 to 10,
2 wherein said polyfunctional (meth)acrylate has two or more benzene
3 ring structures in one molecule.

1 12. The optical element according to any one of claims 8 to 11,
2 wherein said resin composition comprising, as at least a part of said
3 polyfunctional (meth)acrylate, a di(meth)acrylate represented by the

4 following Formula (1):

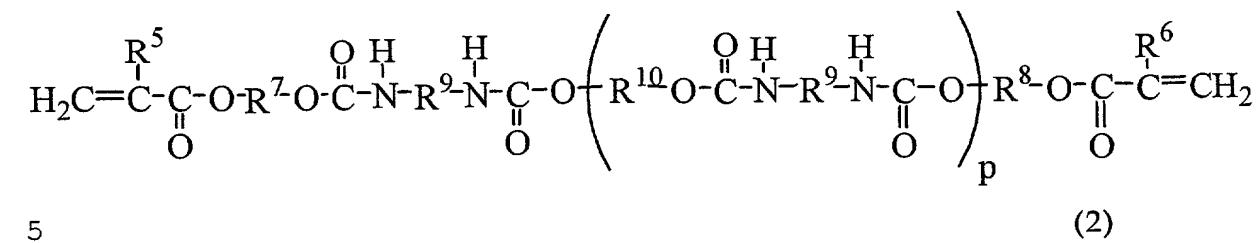


6 wherein R¹ and R² are each a hydrogen atom or a methyl group, R³
7 and R⁴ are each a hydrocarbon group having 2 to 4 carbon atoms, and
8 m and n are each an integer of 1 or more.

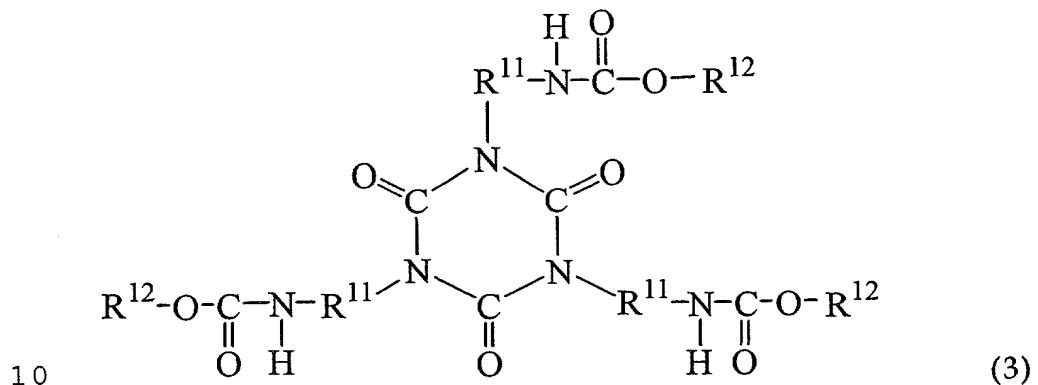
1 13. The optical element according to any one of claims 8 to 12,
2 wherein said polyfunctional (meth)acrylate has a molecular weight
3 before polymerization curing, of 1,000 or less.

1 14. The optical element according to claim 8, wherein said
2 polyfunctional urethane-modified (meth)acrylate has a refractive
3 index before polymerization curing, of 1.48 or more.

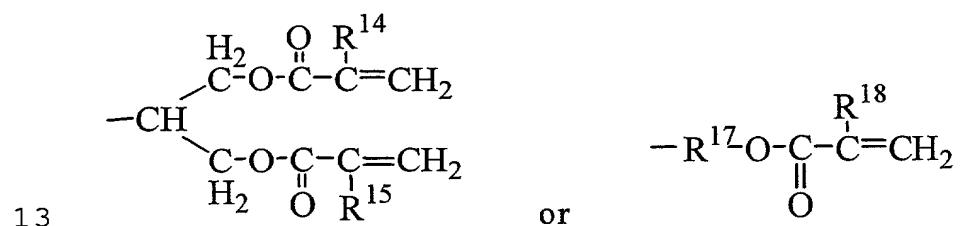
1 15. The optical element according to any one of claims 8 to 14,
2 wherein said polyfunctional urethane-modified (meth)acrylate
3 contains at least one of compounds represented by any of the
4 following Formulas (2) to (4):



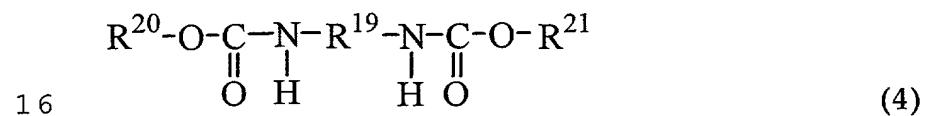
6 wherein R⁵ and R⁶ are each a hydrogen atom or a methyl group, R⁷
 7 and R⁸ are each a hydrocarbon group having 1 to 10 carbon atoms, R⁹
 8 is an isocyanate residual group, R¹⁰ is a polyol residual group or a
 9 polyester residual group, and p is 0 or an integer of 10 or less.



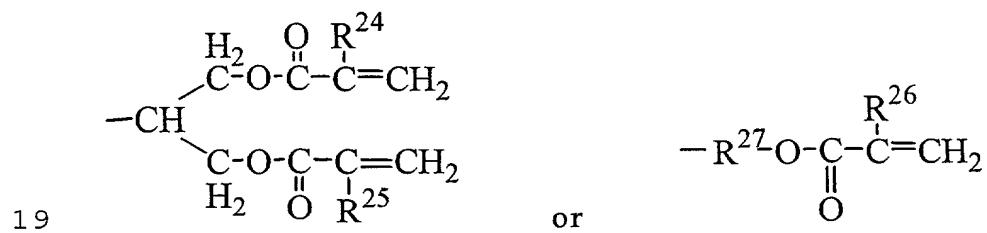
10
 11 wherein R¹¹ is a hydrocarbon group having 1 to 10 carbon atoms, and
 12 R¹² is



13
 14 wherein R¹⁴, R¹⁵ and R¹⁸ are each a hydrogen atom or a methyl group,
 15 and R¹⁷ is a hydrocarbon group having 1 to 10 carbon atoms;



16
 17 wherein R¹⁹ is a hydrocarbon group having 1 to 10 carbon atoms, and
 18 R²⁰ and R²¹ are each



20 wherein R^{24} , R^{25} and R^{26} are each a hydrogen atom or a methyl group,
 21 and R^{27} is a hydrocarbon group having 1 to 10 carbon atoms.

1

1 16. An optical article having the optical element according to
 2 any one of claims 1 to 15.

1 17. The optical article according to claim 16, wherein;
 2 said optical element is a lens; and
 3 said optical article is a still camera.

1 18. The optical article according to claim 16, wherein;
 2 said optical element is a lens; and
 3 said optical article is a video camera.

1

1 19. The optical article according to claim 16, wherein;
 2 said optical element is a lens; and
 3 said optical article is an interchangeable lens.

1 20. A process for producing a resin-cemented optical element,
 2 the process comprising:

3 a first exposure step of irradiating a photosensitive resin
4 composition held between the surface of a base member and a mold
5 tool, to cure the composition to form a resin layer;
6 a mold release step of mold-releasing the resin layer; and
7 a heating step of heating the resin layer,
8 in this order.

1 21. A process for producing a resin-cemented optical element,
2 the process comprising:
3 a first exposure step of irradiating a photosensitive resin
4 composition held between the surface of a base member and a mold
5 tool, with heating to cure the composition to form a resin layer; and
6 a mold release step of mold-releasing the resin layer,
7 in this order.

1 22. The production process according to claim 21, wherein the
2 heating in said exposure step is carried out at a temperature of from
3 40°C to 130°C.

1 23. A process for producing a resin-cemented optical element,
2 the process comprising:
3 a first exposure step of irradiating a photosensitive resin
4 composition held between the surface of a base member and a mold
5 tool, by light with a wavelength of 300 nm or more to cure the

6 composition to form a resin layer; and
7 a mold release step of mold-releasing the resin layer,
8 in this order.

1 24. A process for producing a resin-cemented optical element,
2 the process comprising:
3 a first exposure step of irradiating a photosensitive resin
4 composition held between the surface of a base member and a mold
5 tool, to cure the composition to form a resin layer;
6 a mold release step of mold-releasing the resin layer; and
7 a second exposure step of irradiating the resin layer by light
8 with a wavelength of 300 nm or more,
9 in this order.

1 25. The production process according to any one of claims 20,
2 21 and 23, which further comprises, after said mold release step, a
3 second exposure step of irradiating said resin layer by light with a
4 wavelength of 300 nm or more.

1 26. The production process according to any one of claims 23
2 to 25, wherein at least one irradiation by light with a wavelength of
3 300 nm or more is performed shutting out light with a wavelength of
4 less than 300 nm among light emitted from a light source.

1 27. The production process according to claim 21 or 23, which
2 further comprises, after said mold release step, a heating step of
3 heating said resin layer.

1 28. The production process according to claim 21 or 23, which
2 further comprises, after said second exposure step, a heating step of
3 heating said resin layer.

1 29. The production process according to any one of claims 20,
2 27 and 28, wherein the heating in said heating step is carried out at a
3 temperature of from 40°C to 130°C.

1 30. The production process according to any one of claims 20,
2 21, 23 and 24, wherein said resin composition comprises:
3 (A) a polyfunctional (meth)acrylate;
4 (B) a polyfunctional urethane-modified (meth)acrylate; and
5 (C) a photopolymerization initiator.

PCT/JP00/04922

ABSTRACT

This invention provides a resin-cemented optical element comprising a base member and a resin layer formed on the surface of the base member and comprising a cured product of a photosensitive resin composition, and the resin layer has (1) a refractive index of 1.55 or more, (2) a visible-light inner transmittance of 95% or more in a 100 μm thick area, (3) a rate of hygroscopic dimensional change of 0.4% or less, (4) a durometer hardness of HDD 70 or more, (5) a gel percentage of 95% or more, (6) a glass transition temperature of 95°C or above or (7) a rate of shrinkage on curing of 7% or less; and a production process for the element and an optical article having the element.

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FIG.1

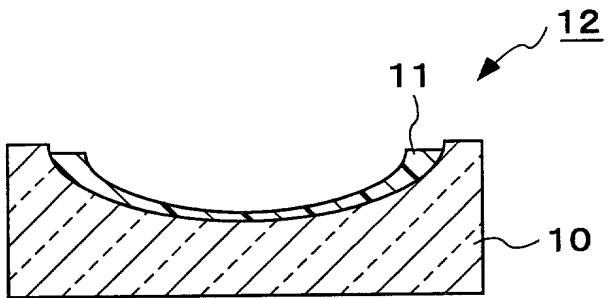


FIG.2

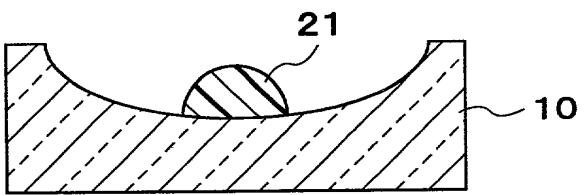
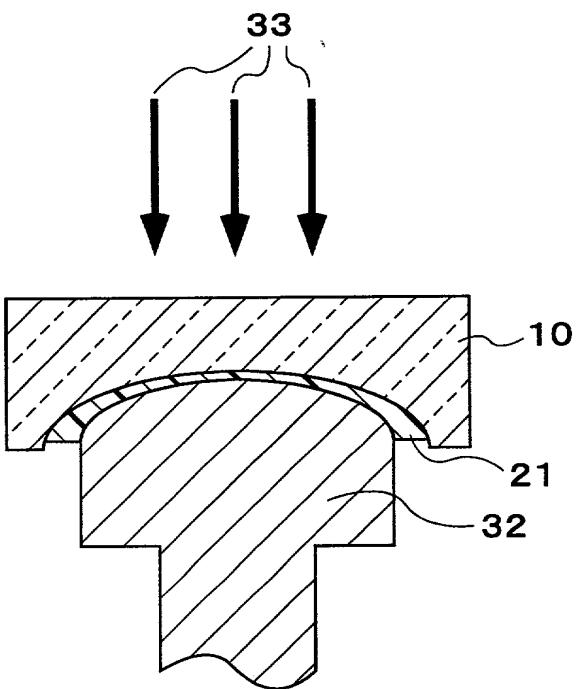


FIG.3



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FIG.4

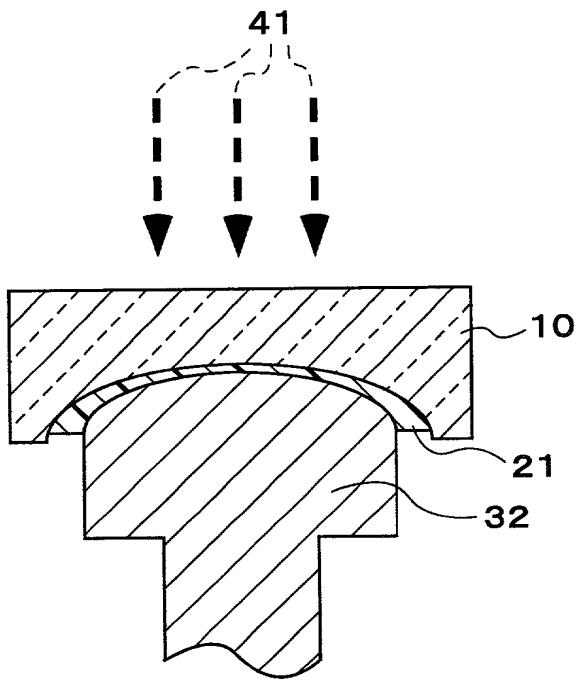
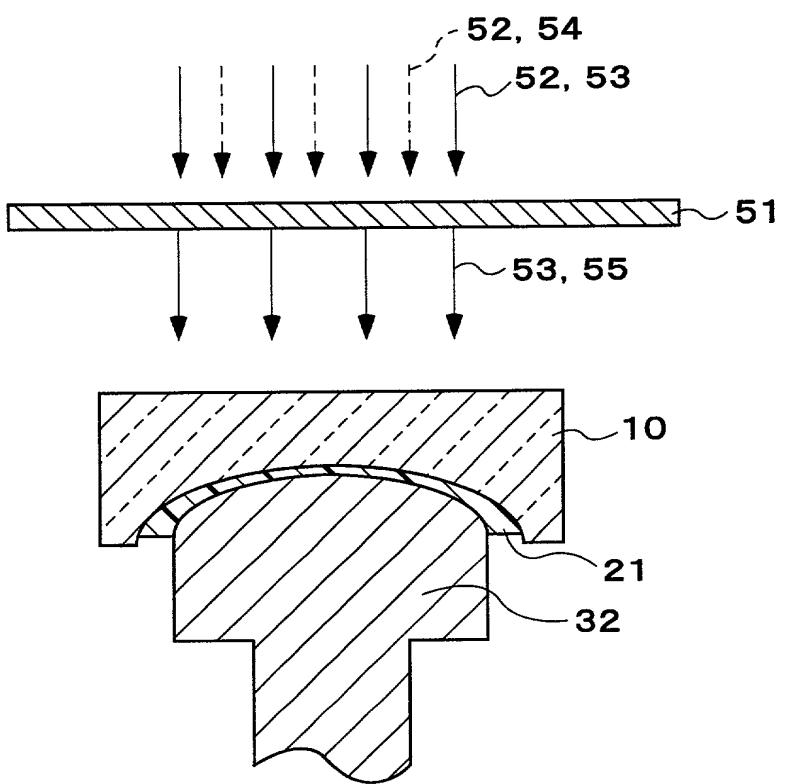


FIG.5



Declaration and Power of Attorney for Patent Application

特許出願宣言書兼委任状

Japanese Language Declaration

私は、下欄に氏名を記載した発明者として、以下のとおり宣言する：

私の住所、郵便宛先および国籍は、下欄に氏名について記載したとおりであり、下記名称の発明に関し、特許請求の範囲に記載した特許を求める主題の本来の、最初にして唯一の発明者である（一人の氏名のみが下欄に記載されている場合）か、もしくは本来の、最初にして共同の発明者である（複数の氏名が下欄に記載されている場合）と信じ、

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name. I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled:

RESIN-CEMENTED OPTICAL ELEMENT, PROCESS FOR ITS PRODUCTION AND OPTICAL ARTICLE

その明細書を
(該当するものにチェック)
ここに添付する。

____年____月____日に

出願番号第_____として提出され、

____年____月____日に補正し、
(該当する場合)

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the specification of which
(check one)
 is attached hereto.

was filed on July 24, 2000 as

Application Serial No. PCT/JP00/04922

and was amended on February 15, 2001 and
July 16, 2001
(if applicable)

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information which is material to patentability as defined in Title 37, Code of Federal Regulations, §1.56.

I hereby claim foreign priority benefits under Title 35, United States Code §119 of any foreign application(s) for patent or inventor's certificate listed below and/or any U.S. provisional application(s) listed below and have also identified below any foreign application for patent or inventor's certificate having a filing date before that of the application on which priority is claimed:

Prior foreign and/or provisional applications 先行外国出願/仮出願			Priority claimed 優先権の主張	
11-209345 (Number/番号)	Japan (Country/国名)	23/July/1999 (Day/Month/Year Filed/提出年月日)	<input checked="" type="checkbox"/> (Yes/はい)	<input type="checkbox"/> (No/いいえ)
11-271738 (Number/番号)	Japan (Country/国名)	27/September/1999 (Day/Month/Year Filed/提出年月日)	<input checked="" type="checkbox"/> (Yes/はい)	<input type="checkbox"/> (No/いいえ)
			<input type="checkbox"/> (Yes/はい)	<input type="checkbox"/> (No/いいえ)
			<input type="checkbox"/> (Yes/はい)	<input type="checkbox"/> (No/いいえ)

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I hereby claim the benefit under Title 35, United States code, §120 of any United States application(s) listed below and, in so far as the subject matter of each of the claims of this application is not disclosed in the prior United States application in the manner provided by the first paragraph of Title 35, United States Code, §112. I acknowledge the duty to disclose material information as defined in Title 37, Code of Federal Regulations, §1.56 which occurred between the filing date of the prior application and the national or PCT international filing date of this application:

(Application Serial No./出願番号)	(Filing Date/提出日)	(Status: Patented, Pending, abandoned/ 現状:特許成立、係属中、放棄済み)
(Application Serial No./出願番号)	(Filing Date/提出日)	(Status: Patented, Pending, abandoned/ 現状:特許成立、係属中、放棄済み)

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Full name of sole or first inventor/単独または第一発明者の氏名 <u>Akiko Miyakawa</u>	
Inventor's signature/同発明者の署名 <u>Akiko Miyakawa</u>	Date/日付 <u>Jan. 15, 2002</u>
Residence/住所 <u>Sagamihara-shi, Kanagawa-ken, JAPAN</u>	JPX
Citizenship/国籍 Japan	
Post Office Address/郵便宛先 c/o NIKON CORPORATION, 2-3 MARUNOUCHI 3-CHOME, Chiyoda-ku, Tokyo 100-8	
Full name of second joint inventor (if any)/第二共同発明者の氏名(該当する場合) <u>Toru Nakamura</u>	
Second inventor's signature/第二発明者の署名 <u>Toru Nakamura</u>	Date/日付 <u>Jan. 15, 2002</u>
Residence/住所 <u>Kawasaki-shi, Kanagawa-ken, JAPAN</u>	JPX
Citizenship/国籍 Japan	
Post Office Address/郵便宛先 c/o NIKON CORPORATION, 2-3 MARUNOUCHI 3-CHOME, Chiyoda-ku, Tokyo 100-8	

Supply similar information and signature for third and subsequent joint inventors

第三又はそれ以後の共同発明者に 대해서も同様な情報および署名を提供すること。

Full name of third joint inventor (if any)/第三共同発明者の氏名(該当する場合)	
Third inventor's signature/第三発明者の署名 Masahito Suzuki	Date/日付 Jan, 15, 2002
Residence/住所 Kawasaki-shi, Kanagawa-ken, Japan	JPX
Citizenship/国籍 Japan	
Post Office Address/郵便宛先 c/o NIKON CORPORATION, 2-3 MARUNOUCHI 3-CHOME, Chiyoda-ku, Tokyo 100-8	
Full name of fourth joint inventor (if any)/第四共同発明者の氏名(該当する場合)	
Fourth inventor's signature/第四発明者の署名	Date/日付
Residence/住所	
Citizenship/国籍	
Post Office Address/郵便宛先	
Full name of fifth joint inventor (if any)/第五共同発明者の氏名(該当する場合)	
Fifth inventor's signature/第五発明者の署名	Date/日付
Residence/住所	
Citizenship/国籍	
Post Office Address/郵便宛先	
Full name of sixth joint inventor (if any)/第六共同発明者の氏名(該当する場合)	
Sixth inventor's signature/第六発明者の署名	Date/日付
Residence/住所	
Citizenship/国籍	
Post Office Address/郵便宛先	

Supply similar information and signature for seventh and subsequent joint inventors
第七又はそれ以降の共同発明者に対しても同様な情報および署名を提供すること。